THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. I.

No. XI.—NOVEMBER, 1904.

ORIGINAL ARTICLES.

I.—Note on the Gigantic Land Tortoise (*Testudo Ammon*, Andrews), from the Upper Eocene of Egypt.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

(PLATE XVII.)

In the course of his excavations in the Upper Eocene beds of the Fayûm during the early part of 1902, Mr. H. J. L. Beadnell unearthed a remarkably fine shell of a very large species of *Testudo*. A brief description of this specimen [1] was afterwards published in Cairo by the present writer, and it was made the type of a new species, *Testudo Ammon*. At the same time Mr. Beadnell gave a short account of the beds in which it was found, and of the methods employed by him for its preservation and transport to the Museum in Cairo.

Owing to the fact that when the original description was drawn up the shell was still imperfectly freed from matrix, some mistakes were made, the most important being the statement that there was no epidermal nuchal shield. It can now be seen that this was present, though it happens that in the type-specimen it is smaller and less distinctly marked than in other shells since found, including several specimens in Cairo and two in the British Museum.

Plate XVII is a side view of the type-specimen, and the diagram in the text (p. 528) shows the structure of the carapace in this species. Seen from above, the shell is somewhat quadrate in outline, owing to the prominence of the slightly everted antero-lateral and postero-lateral portions of the border. The carapace is strongly arched, and the vertebral shields form prominent bosses, separated from one another and from the costals by deep depressions; the costals themselves are also somewhat convex. The anterior border of the carapace is slightly emarginate, and there was an epidermal nuchal shield. There are seven neural bones and three pygals; the latter form a protective covering for the tail and project below the level

[1] "A Preliminary Notice of a Land Tortoise from the Upper Eocene of the Fayûm, Egypt," by C. W. Andrews and H. J. L. Beadnell, Survey Department, Cairo, 1903.

of the rest of the border of the carapace. They are very convex, both from side to side and from above downwards, and were covered by the last neural and the pygal shields.

The sides of the bridge between the plastron and the carapace are greatly thickened and form a prominent border. The plastron itself is larger, and the openings of the shell were consequently smaller, and the soft parts therefore better protected than in most of the later gigantic species of the genus; possibly this peculiarity

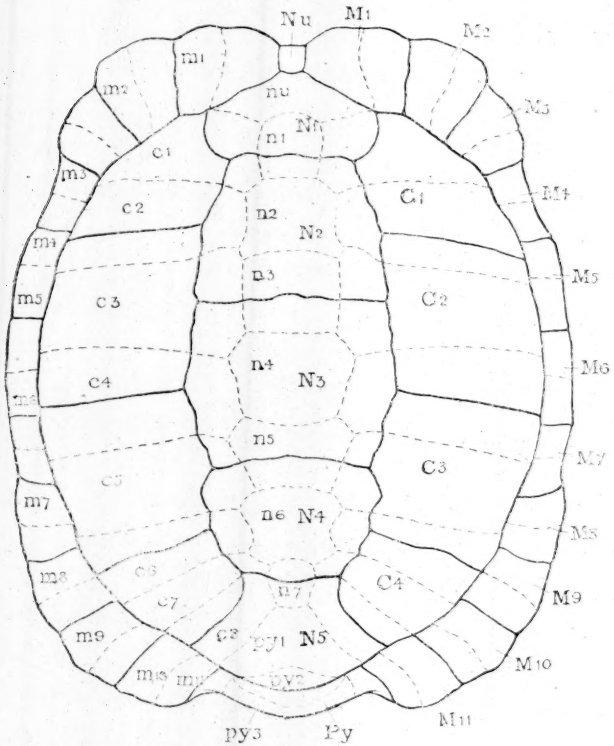

Diagram of carapace of *Testudo Ammon*. *C* 1–4, costal shields; *M* 1–11, marginal shields; *N* 1–4, neural shields; *Nu*, nuchal shield; *Py*, pygal shield. *c* 1–8, costal bones; *m* 1–11, marginal bones; *n* 1–7, neural bones; *nu*, nuchal bone; *py* 1–3, pygal bones. The outlines of the bones of the carapace are marked in dotted lines, those of the epidermal shields in black lines.

may be connected with the circumstance that large and powerful carnivores coexisted with the present species, while most of the more recent types are or were inhabitants of islands in which no such powerful enemies are found. In some of the earlier Tertiary species of Europe (e.g. *Testudo gigas* of the Upper Oligocene of France) the plastron is likewise large, possibly for a similar reason.

In the type and in several other specimens the epiplastral region is produced forwards so as to project considerably beyond the anterior border of the carapace; this epiplastral prominence, like the deep concavity of the middle portion of the plastron, is probably a male character. In the Museum at Cairo there is a beautifully preserved shell of which the carapace differs very slightly from that of the type (e.g. in the smaller degree of convexity of the vertebral shields), while the plastron is very dissimilar. In the first place it is only slightly concave, then the epiplastral region, though prominent, is not produced forward in the same way, and lastly the portion of the xiphiplastrals covered by the anal shields is much narrower, so that the posterior emargination of the plastron is narrower and its angle more acute; this specimen may be regarded as probably the female form of the present species.

The dimensions of the type-specimen (Plate XVII) are:—

Length of the carapace in a straight line	87	cent.
Length of carapace along curve	118	,,
Width of carapace in straight line	76	,,
Width of carapace along curve	115	,,
Length of plastron (greatest)	85	,,
Width of anterior lobe of plastron	32	,,
Width of posterior lobe ,, ...	34	,,
Width of episternal prolongation	15	,,

The dimensions of the female specimen are much smaller; some of these are:—

Length of carapace	51·3	cent.
Width of carapace	34·5	,,
Length of plastron...	45·2	,,
Width of anterior lobe of plastron	21	,,
Width of posterior lobe	22·5	,,

In the former account, owing to the fact that the presence of a nuchal shield was not recognised, it was stated that these species approached the Galapagos tortoises rather than those of the African islands. Now, however, it seems possible that there may be some relationship with the species inhabiting Madagascar and the Aldabra Islands, a much more probable suggestion.

The presence of the nuchal shield, on the other hand, separates this form somewhat more widely from some of the Tertiary species with which it has been compared. Nevertheless, in many respects it is similar to *Testudo perpiniana*, described by Depéret and Donnezan from the Lower Pliocene of Roussillon, and it may also be allied to *T. léberonis*, Depéret, from the Miocene of Mount Lebéron, and *T. gigas*, Bravard, from the Upper Oligocene of the Allier.

As was suggested in the former note, "it seems probable that in the present species we have an early representative of a large group of tortoises, members of which occur at several horizons in the Tertiary beds of Europe, and of which *T. pardalis* and *T. calcarata* may be modern forms. *T. Atlas* and *T. Cautleyi*, of the Siwalik Hills, and the still existing *T. Sumeirei*, of Mauritius, may also fall into this group." To this it may be added that probably the giant species of Madagascar and the Aldabra Islands are also related.

EXPLANATION OF PLATE XVII.

Shell of the type-specimen of *Testudo Ammon*, photographed from the side. Reduced to about $\frac{1}{6}$ natural size. From the Upper Eocene beds of the Fayûm, Egypt. Reproduced from a photograph made in the Geological Museum, Cairo: copied with the permission of Captain H. G. Lyons, F.G.S., the Director-General of the Geological Survey of Egypt. The original specimen was obtained by H. J. L. Beadnell, Esq., F.G.S., of the Geological Survey, during his excavations in the Fayûm early in 1902.

II.—Note on the Lower Culm of North Devon.

By Arthur Vaughan, B.A., D.Sc., F.G.S.

In the Geological Magazine, August, 1904, pp. 392–403, Dr. Wheelton Hind describes the Lower Culm beds of North Devon and assigns them to the 'Pendleside' series.

From the original paper[1] dealing with that series I gather that in the North of England the 'Pendleside' beds lie *above* the uppermost zone of the Carboniferous Limestone, and are the equivalents of the Millstone Grit of the South Wales and Mendip areas. Dr. Hind's contention is, then, that the Lower Culm of North Devon was laid down at a time *subsequent to the deposition* of the whole of the Carboniferous Limestone of the Mendips and South Wales.

The Carboniferous Limestone of South Wales, Chepstow, Bristol, and the Mendips lies but a short distance N.E., N., and N.W. of the Culm crop. It seems then highly probable that, if any difference exists, the faunal sequence in North Devon will resemble that of the neighbouring areas, rather than that of Lancashire and the Midlands.

It is, without doubt, an astonishing instance of the geographical inversion of the faunal sequence that Brachiopods and Corals which, in the North, occur in supra-Viséan beds should, in the South, be only characteristic of infra-Viséan rocks.

Remarkable as this phenomenon unquestionably is, it scarcely affects the purpose of this note, which is to demonstrate that, *if the faunal sequence in North Devon is identical with that in the neighbouring areas*, the Lower Culm must be placed, not above the Viséan, but well below the uppermost limit of the Tournaisian or lower division of the Carboniferous Limestone.

If the Carboniferous Limestone be studied in the extreme west at Tenby, in the neighbourhood of Severn Tunnel Junction, or in the Forest of Dean, in the Sodbury and Bristol areas, or at its most southerly crop in the Mendips, the faunal sequence is essentially the same at all points; furthermore, this result is deduced from continuous sections in which there is no possibility of misreading the order of the beds. Throughout the Carboniferous Limestone outcrop which lies nearest to the Culm of North Devon the faunal facies varies from zone to zone, but the same fossil *assemblage* always characterizes the same horizon, even if the points at which

[1] "The Pendleside Group at Pendle Hill, etc.," by Dr. Wheelton Hind and Mr. J. A. Howe: Q.J.G.S., vol. lvii (1901), p. 388.

it is examined lie 100 miles apart, as in the case of Tenby and the Mendips.

(The detailed demonstration of this fact is fully set out in a forthcoming paper, of which an abstract has already been published.[1] From this abstract it is only necessary to extract the following information: The *Cleistopora* zone is succeeded by the *Zaphrentis* zone, and the *Zaphrentis* zone by the *laminosa* subzone, and these three zones make up the Tournaisian or lower division of the Carboniferous Limestone.)

I am much indebted to Mr. J. G. Hamling, F.G.S., of Barnstaple, for his kindness in sending me, for examination at my leisure, the Brachiopods and Corals which he has collected from Coddon Hill and neighbouring localities. These specimens are mostly casts, but this character increases rather than lessens the certainty of their determination. The arrangement of the muscular scars in the Brachiopods and the grouping of the septa, the nature of the fossula, and the cystoid tabulæ of the *Zaphrentes* are beautifully shown in many of the specimens. I have also been able to compare Mr. Hamling's specimens with a large series of very similar casts collected by myself at Undy (about two miles west of Severn Tunnel Junction), where a similar faunal assemblage is to be found.

The results of my examination are as follows:—

Coddon Hill and Landkey.	South of South Aller; North-west of South Molton.
Chonetes Hardrensis,[2] vars.	*Cleiothyris Reyssii* (mut. β).
Leptena analoga.	*Chonetes Hardrensis*,[2] var.
Rhipidomella Michelini.	*Spirifer* aff. *clathratus*.
Cleiothyris glabristria.	
Orbiculoidea, sp.	
Zaphrentis aff. *Phillipsi*.	

All the specimens from which the above lists are drawn up are not merely similar, but are actual duplicates of forms which occur in the neighbouring areas at the horizons to which I assign the beds; hence the deductions here drawn require no effort of palæontological subtilty.

In the surrounding area every one of the above fossils to which I have assigned a specific name (i.e. with the exception of *Orbiculoidea*) is confined to the Tournaisian, and *does not occur in any higher beds.*

I further deduce from the above faunal lists that the Coddon Hill Beds belong certainly to the *Zaphrentis* zone, but that those near South Molton lie at a somewhat lower level, and may be either upper *Cleistopora* zone or the lowest part of the *Zaphrentis* zone. Assuming, then, that the *Posidonomya* shales lie immediately above the Coddon Hill Beds (a fact of which both Dr. Hind and Mr. Hamling are convinced), my conclusions seem to be in agreement

[1] Abstract of Proc. Geol. Soc., June 8th, 1904.

[2] *Hardrensis* is merely used as a connotative term, and for this purpose it is preferable to *laguessiana*, which implies a particular member of the circulus.

with those of Dr. J. H. Parkinson, who refers[1] similar beds in Germany to the Tournaisian division.

Since writing the above note Mr. T. F. Sibley, B.Sc., has drawn my attention to two specimens of a coral which he had himself obtained from Coddon Hill, from beds in which he found none of the fossils enumerated in the above lists. This coral is, I have little doubt, the species of *Cyathophyllum* which characterizes the upper beds of the *laminosa* subzone in the Mendip, Bristol, and South Wales areas. Not only, then, do the Brachiopods and Corals of the typical Coddon Hill Beds agree with those which are characteristic of the main *Zaphrentis* zone in the surrounding areas, but higher and lower horizons in the Tournaisian division seem also to be represented in the immediate neighbourhood.

It is necessary, however, to state that I am not personally acquainted with the Coddon Hill district, and that my knowledge of the fossils is entirely derived from specimens collected by other geologists.

III.—Notes on the Rhætic Rocks around Charfield, Gloucestershire.

By L. Richardson, F.G.S.

THE object of this communication is to record some recently-made notes on the Rhætic beds of the neighbourhood of Charfield.

In 1876 Mr. H. B. Woodward, F.R.S., wrote: "Turning to the escarpment of Penarth beds between Tites Point and Wickwar, we find them exposed in many places. Long ago Sir Roderick Murchison stated that 'passages from the Lias into the underlying New Red Sandstone can be observed in the sides of Whitecliff Park Hills, south of Berkeley; but the clearest and best instances are to the east of Wickwar, near Sturt Bridge, on the sides of the new road ascending to Wotton.'"[2] This is all that has been written on the area now under consideration. As is well known, the junction of the Rhætic and Keuper Series is usually marked by a low but distinct escarpment. Between Tites Point and Berkeley Road Station this physical feature is not pronounced, but becomes gradually more prominent to the south of the Junction.

At Standhill Green, near Stinchcombe, a section of considerable interest can be studied in the banks and bed of a small brook. Its position is approximately indicated by an arrow on the Geological Survey Map, Sheet xxxv.

Section in Brook at Standhill Green, Stinchcombe.

		ft.	ins.	
Upper Rhætic.	1. Limestone mixed with marl.			
	2. Pale-yellow marls much disturbed.			
	3. *Estheria*-bed, 2 to 6 inches . .	0	4	*Lycopodites lanceolatus*, *Estheria minuta*, var. *Brodieana*.
	4. Pale-yellow marls . . . about	6	0	Full of shell-fragments.

[1] Geol. Mag., June, 1904, pp. 272–276.

[2] Mem. Geol. Surv., "Geology of East Somerset and the Bristol Coalfields" (1876), p. 74; see also "Silurian System," p. 449.

		ft.	ins.	
Lower Rhætic.	5*a*. Shales, dark, marly . . about	1	0	Shell-débris.
	5*b*. Limestone, hard, dark-grey, arenaceous, 0 to 3 inches	0	2	*Gyrolepis Alberti* (scale), *Pecten valoniensis*.
	6. Shales, thickly laminated . about	1	6	*Cardium cloacinum*, *Protocardium rhæticum*, *Schizodus Ewaldi*, *Avicula contorta*, *Modiola* sp.
	7. Limestone, dark-grey, almost rubbly, earthy, 2 to 3 inches .	0	3	*Schizodus*, *Protocardium rhæticum*, *Placunopsis alpina*.
	8. Shales, black, somewhat firm, seen	0	6	
	[*Gap.*]			
	9. Shales, black, thinly laminated, seen	2	0	*Schizodus Ewaldi* (rare).
	10. Shales, black, laminated, with			
	11. yellow streaks	1	9	
	12. Shales, dark-grey, non-laminated, micaceous	0	10	Crowded with *Schizodus Ewaldi*; *Pleurophorus angulatus*, *Protocardium rhæticum*, *Avicula contorta*.
	13. Sandstone, usually very pyritic .	0	1	Scales and teeth of *Gyrolepis Alberti*, *Plesiosaurus* (small tooth), *Acrodus minimus*?
	14. Shales, black, often sandy . . .	0	2	
	15. Sandstone, light-grey, calcareous, sometimes pyritic, 2 to 4 inches	0	3	*Gyrolepis Alberti* (scales), casts of *Schizodus* (?).
Keuper.	I. 'Tea-green Marls,' seen . . .	1	8	

The beds from the 'Tea-green Marls' to No. 9 can be studied in the side of a small pond. Unfortunately it is impossible to obtain the exact thickness of each bed, and the upper portion of the section is considerably obscured. The basement bed is a conspicuous stratum of grey, calcareous sandstone, sometimes pyritic, but with few vertebrate-remains. It forms the bed of the brook at the fence near the little pond. Slightly higher up-stream a thin layer of very pyritic rock can be observed, and if a piece be removed will be found to be separated by a deposit of shale two inches thick from the basal Rhætic bed. This pyritic sandstone (13) occasionally occurs in two layers, the lower being of 'bone-bed' nature. When conjoined, the inferior portion is full of fish-remains. Immediately above are dark-grey, non-laminated shales, crowded with specimens of *Schizodus Ewaldi*, especially at the base. The Lower *Pecten*-bed (7) crops out in the stream, but contains few fossils. The precise thickness of the shale-deposit intervening between this bed and the next limestone band is uncertain. Higher up-stream this second limestone band crops out, and the shale immediately below is excessively fossiliferous, the specimens being very well preserved. *Cardium cloacinum* is especially abundant. Bed 5*b*, however, is intermittent, occurring sometimes in nodule-shaped masses.

In order to study the lower portion of the Upper Rhætic Stage it is necessary to proceed down-stream again, when a steep portion of the bank will be noticed on the left-hand side. At the top of this bank, under the roots of a tree, is the *Estheria*-bed. The phyllopod and the plant-remains, however, are rare: as is usually the case,

they occur in the cream-coloured and less compact portion of the bed.

In the more immediate neighbourhood of Charfield and Wickwar the Rhætic beds crop out in the sides of ramifying valleys of much picturesqueness, but few deeply-cut lanes traverse their sides, and consequently there are few exposures of the beds under consideration. In a field a quarter of a mile due south of Neathwood Farm is a pond in the sides of which limestones and grey marls are exposed, but they are somewhat disturbed. No distinctive fossils were found, but the deposits belong probably to the upper portion of the Upper Rhætic Stage. Fragments of a slightly conglomeratic bed, probably on the horizon of the Cotham Marble, yielded crushed specimens of *Modiola minima* and *Pseudomonotis decussata* and fish-scales (*Legnonotus cothamensis*, Egerton).

Red Marls, 'Tea-green Marls,' and Rhætic black shales are exposed in the sides of Chase Hill Lane. Resting directly upon the 'Tea-green Marls' is the Bone-bed, but it is not a very extensive deposit at this locality, since one or two masses were all that rewarded the writer's investigation. But these are crowded with vertebrate-remains, the fish-scales being unusually large. The matrix in which these fossils are imbedded is a hard, grey, crystalline limestone, with irregular, but nevertheless conspicuously rolled pieces of what appears to be 'Tea-green Marl' marlstone and of less compact green marl. Obscure casts of a *Schizodus*-type of Lamellibranch are not uncommon, and a broad form of *Modiola* was also recorded. There are a few small quartz-pebbles, many coprolites, *Saurichthys acuminatus*, *Acrodus minimus*, *Hybodus minor*, *H. cloacinus*, *Gyrolepis Alberti*, and many other remains in a very fragmentary condition. Above are black shales.

About half a mile to the east of the place where this highly fossiliferous bed was discovered the road branches; that to the right leads into a little valley and crosses a brook near a cottage. In one side of this brook shales are visible underlain by a greenish argillaceous limestone about seven inches thick, with a mammillated surface. In places the limestone passes into marl. This bed may be the equivalent of the *Estheria*-bed, but no fossils were noted.

Close at hand, in the stream-side to the east of the cottage, the Cotham Marble is well exposed, and this is the most northerly point at which the writer has noticed it in its typical form.

Section near Chase Hill, Wickwar.

		ft.	ins.	
Rhætic. Lower Lias.	Shales, pale-green, calcareous, with a few thin hard layers near base.			
	Limestone, dark, earthy	0	1	*Ostrea liassica*, *Modiola minima* (abundant).
	Shale-parting	0	0½	
	Limestone, hard, dark	0	3½	*Ostrea liassica* (abundant), *Modiola minima*.
	Cotham Marble. The top portion is very rubbly; the remainder a good 'landscape stone'	0	5	Fish-scales in upper portion.

A little farther up the stream, bluish-grey shaly clays, with layers of earthy nodules, are exposed. About three-sixteenths of a mile to the south-west of the cottage, Cotham Marble can be seen near a spring.

When stone is required for mending the tracks in the sylvan district composed of Stoneybridge, Bays, Litley, Workhall, and Hawkesbury Woods, shallow excavations are made, and the Cotham Marble is usually laid bare. It is present here in its typical form, and in cracks are frequently found iron-pyrites and barytocelestine, whilst in the upper layers of the marble *Pseudomonotis decussata* is in places abundant. In a quarry near the brook between Bays and Stoneybridge Woods, the Cotham Marble has been worked, and in close proximity to that bed must be limestones with *Psiloceras Johnstoni*. Above are clay-deposits, such as were noted in the stream-side near the cottage to the north of Hawkesbury Wood.

The section in the lane near Sturt Bridge referred to by Murchison is overgrown now, unless it be that in Chase Hill Lane.

IV.—On some Minor British Earthquakes of the Years 1901–1903.

By Charles Davison, Sc.D., F.G.S.

THE number of earthquakes originating within the area of the British Islands during the three years 1901–1903 is 37, of which 9 occurred in England, 20 in Scotland, and 8 in Wales. In the 15 years 1889–1903 the total number recorded is 152, 39 in England,[1] 90 in Scotland, and 23 in Wales. So far as I know, not a single undoubted earthquake has originated in Ireland during this period; but four earthquakes (the Pembroke earthquakes of 1892 and 1893, the Hereford earthquake of 1896, and the Carnarvon earthquake of 1903) were felt in many of the eastern counties.

List of Earthquakes, 1901–1903.

1901.—July 9, 4.23 p.m. Carlisle (principal earthquake).
,, about 4.26 p.m. Carlisle.
,, 4.45 p.m. Carlisle.
July 11, about 11.10 p.m. Carlisle.
Sept. 16, 6.4 p.m. Inverness.
Sept. 18, 1.24 a.m. Inverness (principal earthquake).
,, about 1.35 a.m. Inverness.
,, about 2 a.m. Inverness.
,, about 2.30 a.m. Inverness.
,, about 3 a.m. Inverness.
,, 3.56 a.m. Inverness.
,, 9 a.m. Inverness.
Sept. 23, about 7.30 a.m. Inverness.

[1] Excluding the slight shock felt on Aug. 27, 1895, near Blisland (Cornwall), which may have been caused by a fault-slip precipitated by mining operations.

Sept. 26, 11.40 a.m. Inverness.
Sept. 27, 1.47 p.m. Inverness.
Sept. 28, about 4 a.m. Inverness.
Sept. 29, 9.6 p.m. Inverness.
Sept. 30, 3.39 a.m. Inverness.
Oct. 1, about 4.35 a.m. Inverness.
Oct. 6, 4.24 a.m. Inverness.
Oct. 13, 4.24 p.m. Inverness.
Oct. 22, about 10.15 a.m. Inverness.
Nov. 15, about noon. Inverness.
1902.—April 13, about 11.50 a.m. Hessle (East Yorkshire).
Oct. 14, 5.15 p.m. Strontian (Inverness-shire).
1903.—Mar. 24, 1.30 p.m. Derby (principal earthquake).
,, about 1.45 p.m. Derby.
,, about 5 p.m. Derby.
May 3, 9.22 p.m. Derby.
June 19, about 4.25 a.m. Carnarvon.
,, 10.4 a.m. Carnarvon (principal earthquake).
,, 10.9 a.m. Carnarvon.
,, 10.12 a.m. Carnarvon.
,, 10.16 a.m. Carnarvon.
,, 11.8 a.m. Carnarvon.
June 21, 8.6 a.m. Carnarvon.
July 1, 1.16 a.m. Bala.

The four series of earthquakes, including 34 out of the 37 shocks recorded, have been described in the following papers:—

"The Carlisle Earthquakes of July 9th and 11th, 1901": Quart. Journ. Geol. Soc., vol. lviii (1902), pp. 371–376.

"The Inverness Earthquake of September 18th, 1901, and its accessory shocks": ibid., pp. 377–397.

"The Derby Earthquakes of March 24th and May 3rd, 1903": ibid., vol. lx (1904), pp. 215–232.

"The Caernarvon Earthquake of June 19th, 1903, and its accessory shocks": ibid., pp. 233–242.

The other three shocks, together with some doubtful or spurious earthquakes, form the subject of the present paper. A few earthshakes in mining districts (at Camborne on June 4 and 10, 1902, and Barnsley on October 25, 1903) will be described shortly in a separate paper.

Hessle Earthquake: April 13, 1902.

Time of occurrence, about 11.50 a.m.; intensity, 4; centre of isoseismal 4 in lat. 53° 33·4′ N., long. 1° 11·5′ W.; number of records, 34, from 28 places, and 77 negative records from 76 places. (Fig. 1.)

Hessle lies on the north shore of the Humber, about 4 miles west of Hull. As a rule, the shock was felt only in villages, and, as it occurred on a Sunday during the morning service, I have found it difficult to obtain many records. The only isoseismal that can be drawn is that which corresponds to the intensity 4 (Fig. 1).

It is 34 miles long, 22½ miles wide, and about 600 square miles in area. Its centre lies 15 miles south-west of Hessle, the longer axis being directed from E. 25° N. to W. 25° S. Outside the isoseismal 4, a tremulous motion was also felt under favourable conditions at Clarborough (3½ miles to the south), Hull, Beverley, and Beeford (2½, 7, and 17 miles to the north-east), and Leeds, Horsforth, and Rawdon (24, 28, and 30 miles to the north-west). The sound was also heard at Clarborough, Hull, and Horsforth.

The shock consisted of a single series of vibrations, increasing in intensity to a maximum and then dying away. The average duration of the shock was about 4 seconds.

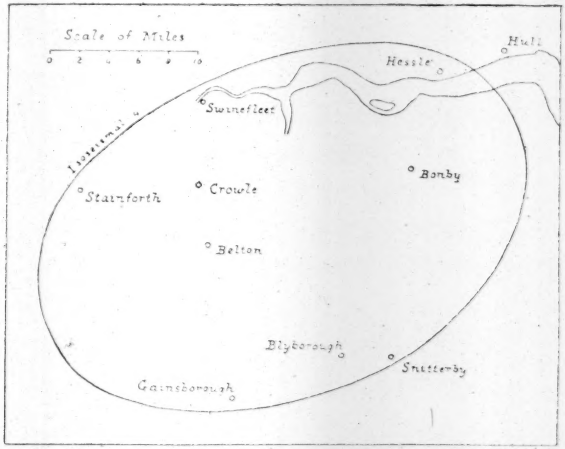

FIG. 1.—Diagram Map of the Hessle Earthquake: April 13, 1902.

The sound was heard by 96 per cent. of the observers; and was compared in 48 per cent. of the records to passing vehicles of various kinds, in 38 per cent. to thunder, and in 14 per cent. to wind. The beginning of the sound preceded that of the shock in 42 per cent. of the records, coincided with it in 50, and followed it in 8 per cent.; the end of the sound preceded that of the shock in 10 per cent., coincided with it in 50, and followed it in 40 per cent.

With regard to the origin of the earthquake, I can offer no suggestion, except that the direction of the originating fault was probably about E.N.E. and W.S.W. On the Geological Survey map of the district (Sheet 86) only one fault is marked, and this is 4 or 5 miles from the epicentre and inclined to the longer axis of the disturbed area.

STRONTIAN EARTHQUAKE: OCT. 14, 1902.

Time of occurrence, about 5.15 p.m.; intensity, 5; centre of isoseismal 5 in lat. 56° 44·4′ N., long. 5° 30·5′ W.; number of records, 47, from 38 places, and 38 negative records from 33 places. (Fig. 2.)

The curves in Fig. 2 represent isoseismal lines of intensities 5 and 4. The former curve, which is the less accurately drawn of the two, is 38½ miles long, 22 miles wide, and 670 square miles in area. Its centre is situated 4 miles N. 10° E. of Strontian, and its longer axis runs from E. 36° N. to W. 36° S. The isoseismal 4 is 49 miles long, 31 miles wide, and contains 1,180 square miles. Its longer axis is parallel to that of the isoseismal 5; the distance between the two curves, as drawn, being 5 miles towards the north-west and 4 miles towards the south-east. Outside this isoseismal, the sound was heard at Kinlochhourn, Roy Bridge, and Fasnacloich, the shock being also felt at the last-named place. All three places are 4 miles from the isoseismal, and lie respectively towards the north, east, and south-east.

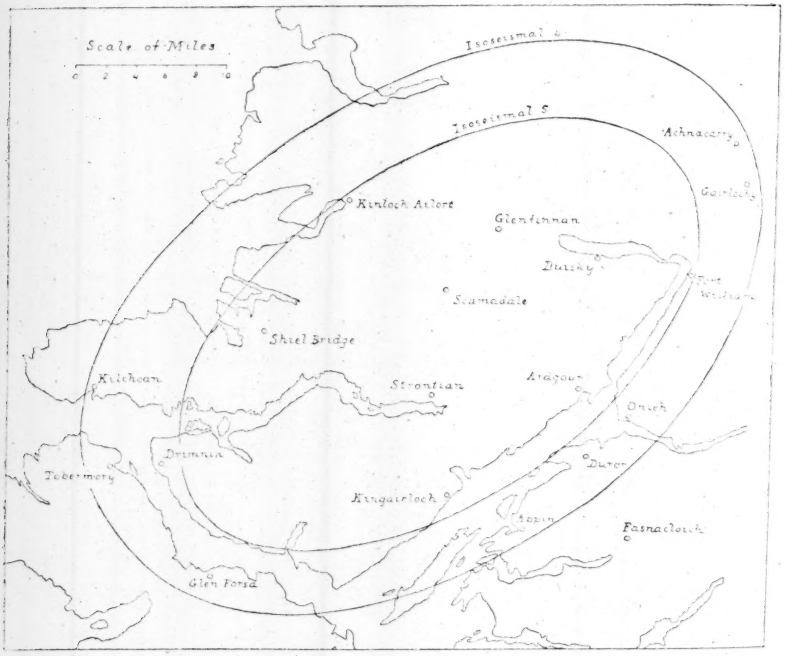

FIG. 2.—Diagram Map of the Strontian Earthquake: Oct. 14, 1902.

The shock consisted of a single series of vibrations, which increased in intensity and then died away, the average duration of the movement being 3 seconds.

The sound was heard by 98 per cent. of the observers. It was compared to a passing train or heavy vehicle in 43 per cent. of the records, to thunder in 43, wind in 3, and to miscellaneous sounds in 11 per cent. The beginning of the sound preceded that of the shock in 71 per cent. of the records, and coincided with it in 29 per cent.; while the end of the sound coincided with that

of the shock in 40 per cent. of the records, and followed it in 60 per cent. In every case the duration of the sound was greater than that of the shock.

We may infer, from the seismic evidence, that the mean direction of the originating fault is from E. 36° N. to W. 36° S. Its hade is probably to the north-west, and, if so, the fault must pass a short distance to the south-east of the centre of the isoseismal 5, and probably not far from Strontian. It is possible, however, that the course of the isoseismal 5 is not drawn with sufficient accuracy to determine the hade of the fault. Mr. Horne kindly informs me that "the ground has not been surveyed west of Strontian, but the ground between Loch Eil and Glen Gower has been finished and west to Glen Strontian." No faults, he adds, have been detected in the position indicated above, though the Great Glen fault sends off a branch along the west side of Loch Linnhe.

Bala Earthquake: July 1, 1903.

Time of occurrence, 1.16 a.m.; intensity, 4; number of records, 10, from 5 places, and 3 negative records from 3 places.

Most of the records on which this brief account is founded I owe to the kindness of Mr. T. Ruddy, of Palè, near Corwen. The five places at which the shock was felt are Bala, Brynbwlan, Llandderfel, Palè, and Tynddynllan (near Llandrillo); and the three places from which no records are forthcoming are Bryn Tegid, Eryl Aran, and Rhos-y-gwaliau. All of the first five places lie close to the great Bala fault, and it is probable that the earthquake was caused by a slip along this fault or one of its branches. The connection with the fault cannot, however, be considered as proved; for the observations do not provide sufficient places for determining the boundary of the disturbed area. The length of this area in the direction of the fault is about 7 miles.

Mr. Ruddy described the shock at Palè as consisting of a single series of horizontal vibrations, lasting 4 or 5 seconds, increasing in intensity to a maximum and then dying away, the direction of the movement being from west to east. It was accompanied by a rushing noise, which other observers compared to thunder or the beating noise of a motor-car.

Doubtful Earthquakes.

Two slight shocks were felt on October 19 and 22, 1901, in the district surrounding Framlingham, a small town in Suffolk about 14 miles north-east of Ipswich.

Framlingham Earth-shake: Oct. 19, 1901.—Time of occurrence, about 7.25 p.m.; intensity, 4; centre of isoseismal 4 in lat. 52° 12·6′ N., long. 1° 15·0′ E.; number of records, 18, from 11 places, and 27 negative records from 23 places.

With one exception, the places where the shock was felt are included within a nearly circular area 6½ miles long from east to west, 6 miles wide, and containing 31 square miles. Both shock and sound were observed at Rendlesham, 2½ miles south of the

isoseismal; and the sound was also heard, but no shock felt, at Dennington, one mile north-west, and Earl Soham, 3 miles west, of the same curve. The centre of the isoseismal is situated at a point one mile south-west of Swefling and 15 miles north-east of Ipswich.

There was a sudden shock followed by a brief tremulous movement, lasting for a few seconds. The sound was heard by all observers, three of whom compared it to passing waggons, etc., one to thunder, one to the fall of a building, three to the fall of a heavy body, and six to explosions or the firing of a heavy gun. Thus, 9 out of 14 observers make use of types which are of short duration.

Framlingham Earth-shake: Oct. 22, 1901.—Time of occurrence, about 9.15 a.m.; intensity, 4; centre of isoseismal 4 in lat. 52° 12·7′ N., long. 1° 15·2′ E.; number of records, 22, from 13 places, and 27 negative records from 23 places.

With two exceptions, the shock was felt within an area of the same dimensions, and almost exactly the same position, as in the former earth-shake. The shock and sound were noticed at Earl Soham, 3 miles west of the isoseismal 4; the shock was also felt at Snape, one mile to the south-east, and the sound was heard at Cretingham, 3½ miles to the west.

The shock was similar to that of the first earth-shake, consisting of one prominent vibration followed by a tremulous motion, and lasting altogether about 3 seconds. The sound was heard by 18 out of 20 observers, and was compared to thunder in 2 cases, to the fall of a heavy body in 7, and to explosions or the firing of heavy guns in 8 cases; 15 out of 17 comparisons being to types of short duration.

Origin of the Earth-shakes.—While I am unable to point to any definite disturbances as the cause of the earth-shakes, their seismic origin seems to me doubtful for the following reasons:—

(1) The shock was a sudden disturbance followed by a brief tremulous motion.

(2) The sound was compared by nearly half the observers to that of an explosion or the firing of a heavy gun, and by more than three-quarters to types of brief duration.

(3) While inquiries were made throughout the surrounding district, the places from which negative records come are, with one exception in each case, absent from the south-east of the disturbed area.

These conditions seem to me to point to the firing of a moderately heavy gun some distance to the south-east, probably in the neighbourhood of Orford Ness, which is 14 miles S.E. of Framlingham. The shock and sound are such as would be so produced; and, in the immediate neighbourhood, would be assigned at once to their true cause. It is only at a distance of some miles from the origin that they begin to lead to the suspected occurrence of an earthquake. From the intermediate region it is usually difficult in such cases to obtain any records, either descriptive or negative. It is known that

gun-practice is occasionally carried out in the neighbourhood of Orford Ness; but my inquiries (made some time after the occurrence) failed to establish the fact in this case.

Church Stretton: April 4, 1903.—A slight shock, lasting about 3 seconds, and strong enough to make bedroom-ware rattle, was felt at about 2.30 a.m. A rumbling noise preceded the shock. (I am indebted for this notice to Mr. E. S. Cobbold, F.G.S.)

Pontesbury (near Shrewsbury): May 8, 1903.—A very slight shock, without any rumbling noise, was felt at 10.20 p.m. at Pontesbury, and also at Worthen, about 6 miles to the west. (Information received from Rev. W. J. Lightfoot Harrison.)

Ilkley: May 17, 1903.—At 4.50 a.m. Mr. H. Stuart Thompson heard two apparently subterranean reports, like distant explosions, which were immediately followed by a shaking of about 2 seconds' duration.

Saffron Walden: Nov. 1 *and* 6, 1903.—Under the heading of "spurious earthquakes," reference is made to some supposed earthquakes that were caused by the explosion of fireworks on Nov. 1. Mr. Guy Maynard, of the Museum, Saffron Walden, to whom I am indebted for this information, has kindly given me the following notices of disturbances which were distinct from those caused by the fireworks. On Nov. 1, at 7.10 p.m., three distinct series of vibrations, each lasting about 5 seconds with intervals of 3 seconds between them, were felt at Newport, 4 miles south-west of Saffron Walden. No sound was heard with the vibrations. At about 8.45 p.m. Mr. Maynard, while walking a few miles from Walden, heard a long drawn-out rumbling, with two maxima of intensity, and lasting about half a minute. The rolling was too rapid and too loud to be caused by a train. Again, on Nov. 6, at 12.10 a.m., the serjeant of police and constables on night duty at Walden heard a heavy booming noise, lasting about half a minute, and causing the pheasants in the preserved woods round the town to cry out for about five minutes. This, or a similar noise, was also heard at the same time at Stanstead (9 miles to the south of Saffron Walden), with the same effect on the pheasants in the neighbourhood.

Spurious Earthquakes.

Channel Islands and South Devon: April 24, 1901.—Between 1 and 1.45 p.m. five reported earthquakes were observed in Guernsey, and eight at Paignton in South Devon. The disturbance bore a close resemblance to those produced by the firing of heavy guns at a distance. They were of very short duration; windows were shaken, but there was no perceptible tremor of the ground. Observers in Guernsey compared the sounds to thunder or the firing of very heavy guns; but those on the English coast were, as a rule, unconscious of any sound. Yet the impression of an observer at Salcombe was that a cannon had been fired to the south, but "too far away to bring the noise." Trials with heavy guns are said to have been made along the coast of France on April 24. I have not succeeded in ascertaining the place or the hour of the firing; but

there is little doubt, I think, that the reported earthquakes must have been due to a cause of this kind.

West Essex: June 3, 1902.—During the night of June 3 several tremors and rumbling sounds were observed in the west of Essex and parts of the adjoining counties. The times given range from about 11.15 to 11.45 p.m. The resemblance to earthquakes must have been rather close, for several persons accustomed to earthquakes in other countries were convinced that they were of seismic origin. They were, in fact, caused by the firing of very heavy guns which, as I am informed by the Garrison Adjutant at Sheerness, took place at the mouth of the Medway at the times mentioned above. In the north-west quadrant, the places from which records come range without any great break from Chelmsford (22 miles from the mouth of the Medway) to North Mimms and Elstree in Hertfordshire (46 miles) and Little Shelford, near Cambridge (55 miles). At places nearer the Medway than Chelmsford, the disturbances were no doubt attributed without hesitation to their proper cause.

North Wales: June 6, 1903.—Three distinct shocks were felt about 8.10 p.m. at Llandudno and other places in North Wales, and also at Skerries in co. Dublin. So closely did they resemble earthquake-shocks that one of my correspondents in Anglesey refused to believe that they were caused, as they were no doubt caused, by practice with the 38-ton gun and quick-firing guns at Seaforth Battery, near Liverpool. The distance of Skerries from Seaforth is 128 miles.

Saffron Walden: Nov. 1, 1903.—Loud reports, resembling the tipping of bricks, were heard at 12.20 a.m., at about 1.40 p.m., and at 9.30 p.m. They were extremely local, although the first was heard by the police on night duty at a distance of 4 miles. There was no vibration with them, and they were undoubtedly caused, as Mr. Guy Maynard informs me, by large fireworks or dynamite exploded by a young Army officer in the town.

In addition to the above, a few disturbances were felt that were attributed in newspapers to earthquakes, but which have so little resemblance to these phenomena that they should, I think, be regarded as spurious or fanciful, rather than as doubtful, earthquakes. Such were the disturbances reported from Cheadle on July 9, 1902, and Melton Mowbray on Oct. 26, 1903.

V.—On Boulders from the Cambridge Drift, collected by the Sedgwick Club.

By R. H. Rastall, B.A., F.G.S.

DURING the past two years the Sedgwick Club has been at work on the glacial deposits in the neighbourhood of Cambridge, with special reference to the boulders contained therein. As usual, the great majority of the boulders are of local origin, but far-travelled rocks are fairly abundant, and several hundred specimens which appeared likely to be of interest have been collected. By the

kindness of Professor T. McKenny Hughes, F.R.S., about fifty of the more promising types have been sliced.

An examination of this collection shows that a large number can be definitely identified as belonging to certain petrographical districts.

Many specimens are clearly referable to the Devonian soda-bearing intrusions of southern Norway; in this connection special mention must be made of the rhomb-porphyry, of which a considerable number of typical examples have been collected from the district lying to the east, south, and west of Cambridge.

A rather coarse-grained pink rock from Pampisford consists of quartz, felspar, and abundant ferromagnesian minerals. Practically the whole of the felspar is perthite of various kinds. The most common coloured mineral is a green pleochroic soda-pyroxene, which is moulded in a characteristic way on the quartz. There are also a good many small crystals of a deep blue, intensely pleochroic mineral, with an extinction angle up to 14°. This sometimes occurs in parallel intergrowth with the pyroxene. It is identified as arfvedsonite. This slice agrees, down to the minutest details, with Brögger's soda-granite, from the Christiania district.

A specimen from Newnham shows quartz, felspar, and long needles of ferromagnesian mineral. The felspars are very variable in character, and include all types of perthite, and especially microcline-perthite. The coloured mineral is chiefly ægirine; it occurs in very long needles, with a very low extinction angle. There is also a small quantity of arfvedsonite, like that in the rock last described. These two rocks are evidently very closely related.

Another coarse granitic rock from Newnham contains brown biotite and arfvedsonite, and is evidently nearly related to Nordmarkite. A slice from Barnwell shows the peculiar amphibole described by Brögger as kataphorite, along with perthite and abundant nepheline. Many other examples contain similar characteristic minerals, and give evidence of relationship.

Besides the above-mentioned rhomb-porphyries, other acid and intermediate intrusives are very common, and in thin slices they often show characters that seem to connect them with the Christiania family.

The commonest type of quartz-porphyry shows large corroded hexagons of quartz and phenocrysts of perthite, together with some ferromagnesian mineral now represented by irregular aggregates of deep brown and strongly pleochroic biotite. This method of alteration also occurs in some other slightly different rocks. The groundmass is microcrystalline, and often micropoecilitic. This rock is identified by Professor Sjögren as coming from Dalecarlia.

Another common porphyritic rock contains abundant phenocrysts of felspar, both perthite and plagioclase, with a few rounded quartz crystals, in a microcrystalline groundmass of quartz and felspar, with numerous radiating groups of minute crystals of tourmaline.

Porphyritic lavas of intermediate and basic character are very common in the district, and many of them can safely be referred to the Old Red Sandstone volcanic series of the Cheviots and central Scotland. The most abundant is an enstatite-augite-andesite of the usual character.

A porphyrite from Lord's Bridge is remarkable for having a great variety of porphyritic minerals: the most prominent are a plagioclase near to oligoclase, with a secondary border of orthoclase, original orthoclase, biotite, hornblende, and notably sphene; the groundmass is microgranitic, with a tendency to orthophyric structure. A few rounded quartz grains also occur.

Mr. G. Barrow has kindly looked over some selected slices, and he identifies half a dozen of these as belonging to the Garlton plateau and Forth district. These include two specimens of analcime diabase of the Forth Valley type. Some slices of olivine basalt show the glomeroporphyritic structure which is so characteristic of this series.

A rock from Pampisford gravel-pit proves to be an unusually fresh example of a very basic lava: it is a porphyritic rock with phenocrysts of olivine and augite in a groundmass of augite and deep brown glass, with a few laths of felspar. This rock must be classed as a limburgite; its place of origin has not been identified.

Enough work has not yet been done to enable any definite conclusions to be drawn as to the glacial phenomena of Cambridgeshire, but the facts here shortly summarised are sufficient to indicate the presence in this area of a large number of the rock-types which are so characteristic of the glacial deposits of other districts in the east of England, and especially many of the best known Norwegian rocks. So far no rock has been identified from the Lake District or any region to the west of the central watershed of Great Britain.

VI.—River Capture in the Don System.

By the Rev. W. Lower Carter, M.A., F.G.S.[1]

THE river Don has a remarkable semicircular course. Rising in the Middle Grits, west of Dunford Bridge, at 1,500 feet above O.D., it flows eastwards to Penistone (700′), where it makes a bend to the south-east, quickly deepens its valley to 500′, and at Wortley breaks through the great watershed (1000′) of the Grenoside and Wharncliffe grits. It then receives the Little Don, the Ewden, and the Loxley, on its right bank, and falls into the valley of the Sheaf at Sheffield (150′). The Don then makes a rectangular bend to the north-east, following the old valley of the Sheaf to Conisborough, receiving the Rother on its right bank at Rotherham (87′) and the Dearne on its left bank at Denaby (45′). It then traverses the Magnesian Limestone escarpment in a fine gorge, and

[1] Paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

continues past Doncaster in a north-easterly direction to Thorne, where it bends northward towards the Aire. It has, however, been artificially diverted by the Dutch River to the Ouse at Goole.

The history of the present river course is presumed to have commenced when the Pennine anticlinal rose from the Cretaceous sea, and the original consequent streams commenced to run down the dip-slope of the Chalk. Slack Beck (Broadstone Dyke), which is diverted south-east at Ingberchworth by a tributary of the Don, is considered to be the head-stream of the brook that runs by Cawthorne, only a narrow dip in the watershed dividing them. The Don at Penistone (700′) faces a watershed of 700 feet, which forms a dip between Hoyland Swaine (900′) and Thurgoland (810′). Immediately beyond this watershed are the head-waters of the Dove, flowing eastward in direct continuation of the course of the Don above Penistone. The Dove is thus considered to be the beheaded remnant of the Don. The southerly bend of the Don and the cutting of the Wharncliffe gorge are explained as due to river capture by a feeder of the Sheaf. This Wharncliffe stream, with a rapid fall to the Sheaf, was able to capture successively the Loxley, the Ewden, and the Little Don, and then the watershed at Wortley was attacked by a branch of this stream, and on the other side by a feeder of the Don. As the watershed was cut through, the Wharncliffe stream, by reason of its steeper fall, captured the Wortley feeder of the Don and then the Don itself.

(2) *The Dearne.*—At a very early date the Bretton stream must have been captured by the Darton feeder of the Cawthorne stream, as it flows straight at the Woolley Edge escarpment (527′), and therefore must have been captured before the land was reduced to this level. The Dearne flows eastwards, by Barnsley to Cudworth Common, where it makes a rectangular bend southwards, and cutting through the Upper Chevet Rock (225′) at Darfield, enters the old valley of the Dove (100′). This gorge at Darfield proves the extension of the 225-foot contour eastwards, towards Hickleton, forming the watershed between the Dearne and the Dove, and there is an old river valley at Frickley (200′) between Clayton and Hickleton, which was probably the original course of the Dearne, which flowed through Hampole gorge into the central plain. The Darfield gorge is a case of river capture by a feeder of the Dove. The Dove itself had probably been captured by the Sheaf at a period before the present level of the Magnesian Limestone escarpment was reached by denudation.

(3) *The Rother.*—The original consequents of the Rother are Shire Brook, the Moss, and the Staveley stream. The Shire and Moss probably coalesced and formed the head-waters of the Ryton. The two gorges (330′) uniting at Kiveton are plainly traceable, and have subsequently been used, in all probability, as a channel of glacial overflow. The Moss must have captured the Staveley stream before it was itself captured by the Rother.

The whole inner Don system is thus explainable by a series of river captures, due to the deep cutting of its valley by the Sheaf,

and its consequent predominant power in capturing consequent streams north and south.

The northwards bend of the Don, after its entrance into the central plain, is due to river capture by a feeder of the Aire. The course of the old Don river from Thorne, along the north side of Hatfield Chase to Adlingfleet on the Trent, is clearly traceable, and was the previous channel of the river before its artificial diversion by the Dutch River to Goole.

VII.—The Glaciation of the Don and Dearne Valleys.

By the Rev. W. Lower Carter, M.A., F.G.S.[1]

In studying the geological history of the rivers of the Don system, my attention was specially directed to the evidences of glacial action in the area, with the object of ascertaining whether glaciation had anything to do with the interesting diversions of the Don, Dearne, and Dove. Certain valleys in the area, also, attracted my attention as possessing abnormal features with respect to the present drainage of the district, and I began to inquire what their relations might be to an altered system of drainage during the Glacial Period. The present paper is an attempt to piece together the scattered glacial evidence, and to ascertain the effect that the advance of a glacier from the north and north-east would have on the drainage of this district, and how far the present valleys would help to explain the water-flow under such conditions.

1. *The Glacial Deposits of the Don System.*—These are fragmentary and scattered, and probably but relics of considerable deposits of drift. There are two considerable areas covered with true Boulder-clay in this district—one at Staincross, Carlton, and Royston, near Barnsley, and the other at Balby, near Doncaster—each filling a small valley which, since the Glacial Period, has been slightly removed from the line of direct drainage, and hence has escaped denudation.

The Staincross Boulder-clay, as described in the "Memoir on the Yorkshire Coalfield," consists of two beds of stiff, unstratified till, separated by a thin seam of warp and sand, the lower containing only boulders of Carboniferous Sandstone and Limestone, chert, and a blue, close-grained trap. The upper bed is more sandy, and on the surface have been found many erratics, including a large Shap granite (25 cwt.), Armboth felsite, Threlkeld quartz-porphyry, andesitic ash, rhyolite, etc. These beds fill a hollow cut out of the Woolley Edge Rock; the junction is much shattered and smashed, and large blocks of the sandstone are embedded in the clay. The Yorkshire Boulder Committee report that the country to the north and east of this patch is covered with erratics, and similar Boulder-clays are found at Burton Grange, near Barnsley, and at Ardsley, on the opposite side of the river Dearne. Mr. Walter Hemingway, of

[1] Paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

Barnsley, has recently traced two tongues of this drift into the valley of the Dearne, and has recorded a section of contorted shale with pockets of erratics from the excavation for the Barnsley gasometer.

The Balby Boulder-clay covers an area of about five acres in extent. It occupies part of a small valley in the Magnesian Limestone, which previously was filled with Bunter Sandstone. In three large pits a magnificent section of 40 feet of stiff till is shown which has yielded many erratics, including a Shap granite (2 cwt.), andesites and andesitic breccias, Eskdale granite, St. John's Vale quartz-porphyry, Carboniferous Limestone, chert, Millstone Grit, etc. The Bunter Sandstone on which this till is seen to rest has been scooped out to form a clean, level floor, without any sand or gravel intervening under the clay. In the excavations for the workhouse a section of this till showed masses of Bunter sandstone torn off and embedded in the till.

About half-way along the arc joining Staincross and Balby is another patch of Boulder-clay at Adwick-on-Dearne, containing Carboniferous Sandstone, quartzite, felstone, and encrinital chert. Close to this patch was found a third boulder of Shap granite (15 cwt.). Contiguous to this zone are several patches of gravel containing Carboniferous Sandstone with quartzite and chert, and a boulder of ganister lies on the summit of Wombwell Hill.

Beyond and to the south of this zone are several scattered patches of drift. At Barbot Hall, about one mile north of Rotherham, is a little hill covered with clay containing pebbles of quartz, sandstone, Carboniferous Limestone, and Oolitic rocks. At Masbrough sand and gravel are found containing pebbles of Carboniferous sandstone and quartz rock, and at Sitwell Vale, one and a quarter mile south of Rotherham, is a clay with pebbles and boulders of Carboniferous Sandstone. Near Hooton Roberts are three or four patches of gravel containing Carboniferous Sandstone, with quartz, quartzite, and black chert.

At the western entrance of the gorge of the Don, at Conisborough, a bed of Boulder-clay (about 15 feet thick) is shown at the Ashfield Brick Works (225 feet above O.D.), including Lake Country andesites, Carboniferous Limestone, a talcose schist with garnets, and other rocks. About the same level, on the opposite side of the gorge, at Cadeby, is a patch of drift with Carboniferous Limestone blocks. Mr. H. H. Corbett, of Doncaster, has also kindly told me of a section of Boulder-clay recently exposed in the valley between the railway station and Conisborough Castle. At Sprotborough and Cusworth, on the north side of the gorge of the Don, are patches of drifted sand and pebbles, and from the fields have been ploughed up small boulders of diorite, basalt, Mountain Limestone, ganister, and quartz-porphyry. At Hexthorpe Flats, near Doncaster, striated Carboniferous Limestone with encrinites has been found, and between Hexthorpe and Balby the ground is covered with drifted pebbles and fragments of limestone. The Magnesian Limestone escarpment south of Conisborough is strewed for some miles with patches of drifted pebbles of quartz, sandstone, and Trias.

This evidence points to glaciation from the north and north-east by two movements of ice. Two distinct tills, separated by warp and pockets of sand, are found at Staincross, the lower with Carboniferous boulders and the upper with Lake Country rocks. The drift patches are also of two kinds, one set being of a specially Carboniferous type and the other rich in Lake Country rocks. It is the latter type that forms the Conisborough and Balby clays. In the Balby pits there is also found a large percentage of Middle Coal-measure material, which forms a perplexing mixture to explain.

The author suggests that there was a double glaciation of this area early in the Glacial Period, first by Pennine ice, and secondly by the Tees glacier.

It seems probable that at the commencement of the Glacial Period, before the Irish Sea was filled with ice, the Pennine Chain was an area of great snowfall, and extensive glaciers were formed in the valleys of Western Yorkshire. These glaciers would probably send down considerable streams of ice into the central plain, laden with Mountain and Yoredale limestones, cherts, ganisters, and Carboniferous sandstones. As the Glacial Period advanced the pressure of the Norwegian ice forced the Tees glacier into the Vale of York, and this in its turn would push back the Pennine ice into the lowlands of Airedale and over the low watershed between the Aire and Don, inside the Magnesian Limestone escarpment, where it spreads out westwards and southwards as far as Staincross, Rotherham, and Conisborough. This seems to have been the line of farthest extent of this glacier, which, though it interfered for a time with the drainage of the Don, does not appear to have passed through the gorge at Conisborough.

The country south of Frickley has undergone extensive denudation since the cutting of the Darfield gorge, and it seems probable that this was effected by this ice, and, on its northward retreat, by the deflected drainage of the Aire and Calder, which, as its course eastwards would still be blocked by the advancing Tees glacier, would find a ready route of flow through Frickley gorge. Thus a large quantity of Middle Coal-measures material must have been carried through the Conisborough gorge into the plain at Doncaster, and would probably be suitably situated for the second glacier to carry forward to Balby. As it has been suggested that this material might be due to a glacier moving down the valley of the Sheaf from Dore and Totley, this question has been carefully considered. The geological surveyors do not record any drift in the valley of the Sheaf, and a careful search of the 6-inch contour maps has not disclosed any valleys which could have carried off the drainage of the upper Don if it had been obstructed by such a glacier at Sheffield. It is therefore concluded that no glacier capable of advancing to Conisborough was formed in the valley of the Sheaf.

The retreat of the first glacier may have been due to a lessening of the snowfall on the Pennine watershed, owing to the shifting of the area of greatest precipitation to the west of the Pennine Chain as the Irish Sea became filled with ice. The evidence, then, points

to a second invasion of the Don and Dearne Valleys by ice, the stream this time coming principally from the Tees. This glacier, which had advanced down the central plain, was now, by the retreat of the Pennine ice, enabled to push over the Aire-Don watershed and Magnesian Limestone escarpment. Westwards it abutted against the high land of Woolley Edge, and sent down a lobe of ice at Staincross and Monk Bretton into the valley of the Dearne. This second glacier does not, however, seem to have advanced far south of the Barnsley-Adwick-Conisborough curve, and laid down the upper clay of Staincross, the Shap granites of Royston and Adwick, and the numerous Lake Country erratics of the district to the north and east of the Dearne. This glacier seems to have advanced over the Magnesian Limestone with a south-westerly movement, gradually closing the gorge of the Don and carrying the material of denuded Bunter and limestone beds over the escarpment to the south of Conisborough, of which the pebble drifts are the relics.

This movement does not appear to have extended much farther southwards, as the Kiveton gorge seems to have presented a clear course for the overflow of the lake formed by the damming back of the drainage. The second glacier appears to have retreated north of the Aire before the overflows at the head of Calderdale were in full swing. The Don and Dearne valleys were therefore, in all probability, clear of ice during the later part of the Glacial Period, and have been subjected to enormous denudation, both during the Glacial Period and since, which has cleared away the bulk of the Boulder-clay and only left relics of previously widespread deposits.

2. *Glacial Lakes and Overflow Valleys.*—Such a series of glacier movements as has just been indicated would divert the normal drainage of the district and produce lakes in the valleys thus dammed up. The Boulder-clay at Ashfield's Pit, and near the railway station at Conisborough, and at Cadeby, on the opposite side of the Don, shows that this gorge must have been filled with ice up to the 225-foot contour. The scattered patches of drift from Edlington to Clifton and Braithwell, reaching up to 400 feet, indicate that the gorge was entirely closed above the 350-foot contour. This is the general height of the Midland watershed of the Don system, and is only broken through at one point south of Conisborough, the Kiveton Valley (330 feet), near the middle of which one of the sources of the river Ryton takes its rise. These considerations warrant one in assuming the existence of a great glacial lake, rising to the level of the 330-foot contour to the west and south, and dammed back by ice from Conisborough to Barnsley. This lake would overflow by the Kiveton gorge towards Worksop. One cannot expect to find abundant evidences of lake deposits in an area which has suffered so severely by denudation as this; but the geological surveyors map from 4 feet to 9 feet of brick-earth and clay resting on gravel at Parkgate, and from 3 feet to 7 feet of brick-earth near Wombwell. These indicate a lake both in the Don and Dearne valleys, covering up the old river gravels.

Following this line of argument, and taking the various patches

of drift as the relics of moraines, and therefore as indications of periods of rest in glacial movement, I have attempted to map out the lakes that would be produced at the different positions of the ice-front, and have examined the watersheds to see if overflow channels existed such as would be necessary to drain such lakes. The whole has been plotted out on the 6-inch contoured maps, by which the results have been carefully tested, and a series of lakes made out discharging successfully over cols from 175 feet to 335 feet above O.D. These overflow valleys are not of the type so characteristic of Cleveland and the Cheviots. The long period of subaërial denudation to which they have been subjected has worn back their sides so that they are now V-shaped, but they are streamless either in whole or in part, and often the nearest streams cut across their ends.

In spite of this weathering back there has probably been little alteration of their level, and their present levels may be taken approximately as those of the Glacial Period. Some of them are strike-valleys formed by the denudation of the shales between the outcrop of a bed of Carboniferous Sandstone and the dip slope of a lower grit. The objections against such valleys as overflows have been carefully considered, but as the movement of the ice seems to have brought its margin parallel to the general strike of the Coal-measures of this area, it is natural that the deflected drainage should sometimes escape by such routes. In considering the course of the first glacier, it seems probable that it would dam up the Dearne at Ardsley and form a lake overflowing by the Stairfoot valley at 175 feet. A forward movement would carry it to the Wombwell ridge, and the overflow would be by the Wombwell and Swinton strike-valleys. Further south the ice would probably abut against the projecting spur of the 350-foot contour west of Rawmarsh, and hence would form a lake about that level stretching up to Elsecar, Cawthorne, and Bretton. In searching the watershed for a possible overflow for such a lake, a narrow cut through the 350-foot contour was found at the head of the Wentworth Woodhouse valley, sloping back to the 400-foot contour on each hand, and with a little stream running across each end at right angles to the direction of the col. By this valley at 335 feet the Elsecar lake would be discharged into a smaller lake held up by the ice in the Wentworth Woodhouse valley. When the ice laid down the Masbrough and Sitwell Vale patches of drift the Rother valley would be blocked, and the glacial drainage would be discharged round the lobe of ice by channels at Greasborough and Sitwell Vale at 275 feet, and thence into the Don by the Hooton Roberts valley (180 feet). A slight forward movement of the ice to the gravel patches east of Hooton Roberts would close that valley and cause the drainage to discharge by a col on Conisborough Parks at 260 feet.

The second glacier does not seem to have advanced far beyond the curved line stretching from Barnsley through Adwick-on-Dearne to Conisborough. This, by damming the Dearne at Ardsley, would re-form the Barnsley lake, discharging over the Stairfoot col at

175 feet. This drainage would then escape by a narrow notch between Adwick-on-Dearne and Swinton into the Don at Mexborough.

A further advance would bring the Wombwell-Swinton valleys into use as overflows, and the Hooton Roberts valley would be the route into the Don. The damming of the Dearne at Barnsley by a lobe of ice would bring into use a couple of small valleys at Barnsley as overflow channels. The gradual advance of the ice across the Conisborough gorge would cause the blocking of the Don, with the formation of a constantly enlarging lake, which would overflow first by the Hooton Roberts valley (180 feet), and then by a series of cuts through the 275-foot contour on Conisborough Parks, first draining into the Don behind Castle Hill, then, as the Warmsworth watershed was reached by the ice, into the Balby valley, and, when this was closed by the ice, over the low watershed into the Loversall valley.

The further advance of the ice-front to Edlington caused a shallow cut to be made through the 300-foot contour, discharging into the Loversall valley and thence into the Trent. This channel, which bends round in a semicircle, became the permanent course of the Wadsworth drainage on the retreat of the ice, the old channel at Balby having been filled up with till. When the ice rose above the 330-foot contour the gorge of the Don was entirely closed, and the drainage of the great lake, reaching from Bretton Park and Cawthorne, north of Barnsley, to Clay Cross and Heath, south of Chesterfield, would all be discharged by the Kiveton gorge into the river Ryton.

This explanation may be thought to rest too largely on suggestions, but where the evidence is so scattered and imperfect it is difficult to see how this can be avoided if any explanation is to be attempted.

NOTICES OF MEMOIRS, ETC.

I.—Note on Lower Cretaceous Phosphatic-beds and their Fauna. By G. W. Lamplugh, F.G.S.[1]

IT has been customary to regard the fossils more or less imperfectly preserved in the condition of phosphatic casts in different parts of the English Lower Cretaceous series as derivative from the Jurassic rocks. In previous papers the writer has brought forward evidence to show that the fauna of such beds at Speeton and in Lincolnshire is not derivative, but occurs at its proper horizon and, so far as it goes, indicates the life of the period. Personal investigation of the localities, and of the fossils obtained from the 'coprolite-beds' at Upware, Potton, and Brickhill, has led him to conclude that in these deposits also the greater part of the so-called derivatives are really of Lower Cretaceous age. Thus, one of the

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

most abundant phosphatic fossils of these places is the ammonite, usually fragmentary, which has habitually been named *Amm. biplex*, but belongs in almost every case to one or another of several allied species of Lower Cretaceous Olcostephani. Most of the lamellibranchs can likewise be best matched by Lower Cretaceous forms; and there are good grounds for suspecting that many of the Saurian and fish remains from the above-mentioned places and from the Faringdon 'Sponge-Gravels' which have been classed as Jurassic are true Lower Cretaceous forms.

It is acknowledged that the presence of transported pebbles of older rocks in the deposits at Upware, Potton, and Faringdon renders the occurrence of derivative fossils at these places more probable than in the case of the Speeton and Lincolnshire 'coprolite-beds'; and in the collections examined a few specimens were noticed that seem to have been washed from older rocks. But the writer believes that these instances are exceptional, and he urges that no fossil should be set down as derivative unless the evidence is conclusive, as much confusion has arisen through the unquestioning adoption of the hypothesis of derivation.

While there is still much to be learnt as to the physical conditions requisite for the concretion of phosphatic nodules and for their segregation into bands, it seems clear that an important determinative was the existence of submarine currents occasionally impinging upon the sea-floor with sufficient strength to sweep away the matrix in which the nodules had been formed, so that there was a gradual accumulation of the partially eroded nodular residues. Such residues, though of inconsiderable thickness, may represent a long period of submarine conditions. The term 'aggregate deposits' has been suggested by J. F. Blake for beds of this character.

II.—On the different Modifications of Zircon. By L. J. Spencer, M.A., F.G.S.[1]

SOME very irregularly developed crystals of zircon from the gem-washings of the Balangoda district in Ceylon were found to have characters differing widely from those of zircons of more common occurrence. Although of low specific gravity (4·0), they are not increased in density when strongly ignited, as are many zircons of specific gravity below 4·7. They further differ from ordinary zircon in their very feeble, or absence of, birefringence. The crystals are dark brown in colour and almost opaque, but after ignition they are bright green and quite transparent.

While some of the crystals consist wholly of zircon of this type, others contain an intergrowth of a second kind, which may be present in greater or less amount. The latter has a higher specific gravity, and increases in density when ignited; it is optically biaxial with very strong birefringence. A section cut perpendicular to the

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

principal axis of such a compound crystal shows, when moved across the microscope-stage in convergent polarised light, a gradual transition from a biaxial to a uniaxial figure, the coloured rings at the same time moving outwards and becoming further apart owing to the diminution in the strength of the double refraction, which is positive throughout; finally, when the rings have all moved out of the field of view, the black cross also disappears, and the corresponding portion of the section is optically isotropic. The mean refractive index has about the same value in all portions of the section.

Zircon of the first type has been previously described by Professor A. H. Church (1875) and by Dr. S. Stevanović (1903), and from the researches of these and other authors it would seem that there are, at least, three modifications of zircon, viz.:—

α. Those of specific gravity 4·0, which do not increase in density when ignited.

β. Those of specific gravity 4·7, also not increased in density when ignited.

γ. An unstable form of specific gravity about 4·3, which when ignited is increased in density to 4·7.

That these different kinds are often intergrown in the same crystal is shown by the frequent occurrence of zonal structures in zircon, and further by the behaviour of the crystals when heated. A crystal consisting of an intergrowth of *α*-zircon and *γ*-zircon will be increased in density on ignition, but not to the higher limit of 4·7; on the other hand, an intergrowth of *β*-zircon and *γ*-zircon will reach the higher limit when ignited.

In crystalline form and chemical composition (as far as could be determined by qualitative tests) *α*-zircon and *β*-zircon are identical, and these appear to be also the same for *γ*-zircon.

III.—On Derived Plant Petrifactions from Devonshire. By E. A. Newell Arber, M.A., F.L.S., F.G.S.[1]

SOME interesting plant petrifications in which the structure has been to some extent preserved by means of a mineral agent have recently been discovered in the higher beds of the Upper Culm Measures (Upper Carboniferous) in Western Devon. Although the preservation is not sufficiently good to render this discovery of any botanical importance, the manner in which the fossils occur is interesting from a geological point of view. The plant remains consist of small rolled fragments of stems, of an inch or less in length, arranged without order in a fine-grained sandstone. They are in all probability derived from some pre-existing beds, and are not contemporaneous with the sandstone in which they are found. Such derived plant remains are very rare, if not unknown, from the Palæozoic rocks.

[1] Abstract of report read before the British Association, Cambridge, Section C (Geology), August, 1904.

IV.—On the Fossil Plants of the Upper Culm Measures of Devon. By E. A. Newell Arber, M.A., F.L.S., F.G.S.[1]

THE Upper Culm Measures form by far the largest portion of the Carboniferous sequence in Devon and the adjacent counties. Fossil plant remains are abundant in these beds, but their preservation is rarely sufficiently good to permit of even generic determination. A number of well-preserved specimens have, however, recently been obtained from the one horizon in which coal or 'culm' occurs in these beds in the Bideford district. They include *Calamites undulatus*, *Calamocladus charæformis*, *Alethopteris lonchitica*, *A. Serli*, *Neuropteris obliqua*, *Sigillaria tessellata*, and many others. *Neuropteris Schlehani* and *Megalopteris* (?) sp. are also recorded from Britain for the first time.

This flora confirms the previous conclusions with regard to the Upper Carboniferous age of these beds, and indicates that the coal-bearing beds of the Bideford district are the equivalents of the Middle Coal-measures elsewhere in Britain—a higher horizon than has previously been assigned to these beds.

V.—On the Occurrence of Pebbles of White Chalk in Aberdeenshire Clay. By A. W. Gibb, F.G.S.[1]

THE record of the Cretaceous period in the north-east of Scotland is a very fragmentary one. The principal traces hitherto noted consist of a deposit of the nature of a Greensand—not proved to be *in situ*—at Moreseat, Cruden, and large numbers of flints scattered over the surface of the ground in the same locality between Buchanness and the Hill of Dudwick.

Further indications of Cretaceous strata have recently been found at Strabathie, in the district of Belhelvie—about five miles north of Aberdeen—in a bed of laminated clay close to the sea. The clay is found to contain pebbles of white chalk in considerable abundance. Some of the pebbles measure nearly a foot in length, but the majority are small. Some of them inclose flints. That they have been worn off an adjoining land surface is shown by the fact that numbers of them are markedly glaciated, and that pebbles of other rocks, identical with or similar to the rocks of the district, are found in the same pit. These facts indicate that Upper Cretaceous beds have once been, and perhaps somewhere are still, *in situ* in the locality.

It has been ascertained by boring that the clay deposit covers a considerable area, and as fresh exposures are constantly being made in the process of working the bed further finds may be anticipated.

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

VI.—Edenvale Caves, Co. Clare.—Final Report. By Dr. R. F. Scharff (Chairman), Mr. R. L. Praeger (Secretary), and a Committee appointed to explore Irish Caves. (Drawn up by the Chairman.) [1]

SINCE our last report was submitted to the British Association, Mr. Ussher has completed the excavations of the extensive caves of Edenvale, co. Clare, and sent altogether a collection of more than 50,000 bones to be named. Besides these there were flints and implements used by primitive man and relics of various periods, on which it is proposed to submit a detailed report to the Royal Irish Academy during next winter.

Mr. Ussher has explored other districts of Ireland with the view to continuing the cave researches, but this Committee do not propose to apply for a further grant.

The Edenvale remains have not been fully determined, but so far they have yielded the following species:—

Man (*Homo sapiens*).
Bats (several species).
Hedgehog (*Erinaceus europæus*).
Domestic Cat (*Felis domestica*).
Wild Cat (*Felis caligata*).
Dog (*Canis familiaris*).
Fox (*Vulpes alopex*).
Irish Stoat (*Putorius hibernicus*).
Marten (*Mustela martes*).
Bear (*Ursus arctos*).
Badger (*Meles taxus*).
Arctic Hare (*Lepus timidus*).
Rabbit (*Lepus cuniculus*).
Irish Rat (*Mus hibernicus*).
Field Mouse (*Mus sylvaticus*).
Arctic Lemming (*Dicrostonyx torquatus*).
Domestic Ox (*Bos taurus*).
Domestic Sheep (*Ovis aries*).
Domestic Goat (*Capra ægagrus*).
Domestic Pig (*Sus scrofa domestica*).
Wild Pig (*Sus scrofa ferus*).
Red Deer (*Cervus elaphus*).
Giant Deer (*Megaceros giganteus*).
Reindeer (*Rangifer tarandus*).
Horse (*Equus caballus*).
Birds (many species).
Frog (*Rana temporaria*).
Fishes (several species).
Land Mollusca (many species).

VII.—Brief Notices.

1. Peat Moors of the Pennines.—In an article entitled "Peat Moors of the Pennines: their Age, Origin, and Utilization" (*Geographical Journal*, May, 1904), Mr. C. E. Moss remarks that the Pennine peat moors represent a valuable asset which is turned to little account: not only is there enormous value in products manufactured from peat, but he believes there is fuel enough to last the hillside population for a thousand years.

2. Najas in the Peat.—Mr. Clement Reid records the occurrence of *Najas marina* in the Megaceros-marl of Lough Gur (*Irish Naturalist*, vol. xiii). This little "submerged flowering plant" is known to exist in Britain only at a single spot in Hickling Broad, in Norfolk. It is found in the Cromer Forest-bed Series, and in

[1] Abstract of report read before the British Association, Cambridge, Section C (Geology), August, 1904.

later deposits in England and Wales, but has not hitherto been recorded from Ireland.

3. Rhodesia.—A useful pamphlet on "The Geology of Southern Rhodesia," by Mr. F. P. Mennell, has been issued by the Rhodesia Museum at Bulawayo. This is accompanied by pictorial and other illustrations, and by a sketch geological map on the scale of an inch to four miles. The author deals with the igneous rocks and schists, the coal series, superficial deposits, and scenery.

REVIEWS.

I.—Memoirs of the Geological Survey of the United Kingdom.

The Tertiary Igneous Rocks of Skye. By Alfred Harker, M.A., F.R.S., with Notes by C. T. Clough, M.A., F.G.S. pp. xi, 481, 84 text-figures, 27 plates, and one coloured map. (Glasgow, 1904. Price 9*s*.)

THE appearance of this memoir awakens the echoes of past controversies. The region with which it deals shows within a narrow compass such a complex group of rocks that diversities of opinion might well arise as to their mutual relations. Broadly speaking, two series of igneous rocks occur, an acid and a basic, ranging in both cases from plutonic masses and intrusive sills and dykes to lava-flows; and the views first enunciated, according to which the plutonic masses were regarded as the denuded cores of volcanoes from which the lavas (first the acid and then the basic) had been poured out, appeared to be a simple and reasonable explanation of the facts observed.

As is well known, very different views from the above as to the sequence of these igneous rocks were held by the late Director-General of the Survey, under whose direction, in fact, was planned much of the work the result of which is recorded in the present memoir. The result of Mr. Harker's researches, it may be here briefly stated, has been to convince him of the correctness of Sir Archibald Geikie's main conclusions that the basaltic lavas which cover such an extent of country in the Western Isles of Scotland and in the north of Ireland are amongst the earliest volcanic rocks of the region and were probably due to fissure-eruptions, that the gabbro-masses were intruded into them and are consequently of later date, and that finally these basic rocks were invaded by the granites and granophyres. Supporters of the earlier views will find, therefore, little encouragement in these pages, although here and there a glimpse may be caught of difficulties in the case of phenomena easily capable of misinterpretation, such as the presence in the earlier basic agglomerates of fragments of gabbro and granophyre identical in character with the later rocks which constitute the main mass of the Cuillins and the Red Hills, and the occurrence of basic dykes which traverse certain rocks freely and

end abruptly against others (such as granite and agglomerate), not because the latter are of later date, but owing to the resistance they offered to the passage of the dykes. Like many of the other problems which have confronted Mr. Harker in this region, this last observation is an important one and capable of wide application; for, as he suggests, it may lead to a reconsideration of the age attributed to certain intrusions which intersect the Carboniferous and older strata in parts of England and Wales.

The memoir is confined principally to the area mapped in detail by Mr. Harker during the years 1895–1901, comprising the central laccolitic masses of gabbro and granophyre and their surroundings, the basaltic plateaux to the west and north-west, and some of the islands off the east coast; but the south-eastern part of the island, which was surveyed by Mr. Clough, also receives consideration in the descriptions of the minor intrusions in the older stratified rocks.

After an introduction dealing chiefly with the general relations of the volcanic series, the different rock-groups are treated as far as possible in chronological order, and in each case descriptions are first given of the field relations and then of the petrographical characters. As regards the latter, Mr. Harker has been on the whole merciful, and spared us too great detail: in some cases an additional interest is given to the description of thin-slices by the discussion of the chemical analyses, no less than sixteen of which have been made for the purpose of the memoir by Dr. Pollard.

Although the gabbro and granite masses have been deposed from their position as ancient volcanic cores, yet the remains of vast craters filled with agglomerates have been detected in Skye. These were the vents from which took place the explosive eruptions which marked the earliest phase of igneous activity in the island. The succeeding tranquil fissure-eruptions of basalt were also accompanied and partly succeeded by paroxysmal eruptions of trachyte and rhyolite. In comparison with the basalts, however, the pyroclastic rocks and more acid lavas play but a very minor rôle. A fact with respect to the basalts, which Mr. Harker considers has not been hitherto sufficiently appreciated, is the extent to which their apparent thickness has been increased by the intrusion of dolerite sills of later date. The greater part of the alteration (with production of amygdules) which characterises these basalt lavas is attributed by the author, not to ordinary weathering, but to changes produced in them soon after their eruption by the "action of water of volcanic origin." In the subsequent contact-metamorphism by the gabbro and granite it is these early formed amygdules which show the most interesting effects, viz., a restoration of the minerals (felspar and augite) from which the zeolites and chlorites were originally derived.

To the second or plutonic phase of igneous activity are due the most picturesque features of the scenery of Skye. This phase consisted in the intrusion of laccolitic masses first of ultra-basic rocks, then of gabbro, and lastly of granite and granophyre. The descriptions of the partial fusion and incorporations of the gabbro

by the invading granite magma with the consequent production of hybrid rocks of abnormal chemical and mineral composition, and the detailed accounts of the peculiar composite sills and dykes outside the mountain tract, form perhaps the most important and interesting feature of the memoir. In the case of Skye the author finds that the heterogeneity of these intrusions is invariably due, not to differentiation subsequent to intrusion, but to successive injections of different rock-magmas, the acid magma showing a tendency to be guided by a pre-existing basic dyke or sill.

Of the third and final phase of igneous activity in Skye which was characterised by minor intrusions in the form of sills and dykes, the most important rôle was played by the great group of basic sills previously referred to, which are intercalated among the basaltic lavas to such an extent that they and not the basalts really form the salient features of the plateau country. Amongst a minor group of basic sills an interesting type is the peculiar composite sills of Roineval, to one of the constituents of which the author gives the provisional name of Mugearite. This and Marscoite (a hybrid of gabbro and granite, produced, however, before intrusion) it is a relief to see are the only new rock-names which appear in a memoir which deals with so many rocks of exceptional composition. To the rocks composing most of the basic dykes and sills we are glad to find that Mr. Harker applies the name olivine-dolerite, although he has not been able to avoid altogether the use of his term diabase for some of the coarser-textured types near to gabbro.

In an interesting penultimate chapter is given a general review of Tertiary igneous activity in Skye. As the cause of this activity two distinct elements of crustal strain are recognised, the one regional and probably related to the great Atlantic depression, and the other local: to the first are attributed the fissure eruptions of basalt, the great group of basic sills, and the system of parallel dykes, and to the second the central volcanic eruptions, the plutonic intrusions, and the radial group of dykes peculiar to the Cuillin district.

In the last chapter, the physical features and scenery of the island and their relation to the geology are discussed. A very complete bibliography of the geological literature referring to the igneous rocks of Skye is given in an Appendix.

The memoir is illustrated by 84 text-figures and 27 plates. References to the figures in the text might have been with advantage more often accompanied by indications of the pages on which they occur.

In conclusion, it remains to congratulate Mr. Harker on the completion of an arduous but very successful piece of work, and the Geological Survey on the production of a volume which with its numerous and excellent illustrations can be offered to the public at so low a price.

II.—Stanford's Geological Atlas of Great Britain [based on Reynolds's Geological Atlas], with plates of characteristic fossils, preceded by a Description of the Geological Structure of Great Britain and its Counties, and of the features observable along the principal lines of Railway. By Horace B. Woodward, F.R.S., F.G.S. pp. x and 140, with 34 geologically coloured Maps and 16 double octavo Plates of Fossils geologically arranged. (London, 1904: Edward Stanford, 12–14, Long Acre, W.C. Price 12*s.* 6*d.*)

EVERY well-informed person at the present day is not necessarily a geologist; nevertheless, there are a vast number of people who are more or less *acquainted* with geology (if it is only "a bowing acquaintance," like Mark Twain's with the Prince of Wales). To those more or less interested in this study, and especially for those who have little time to spare, a handy *vade-mecum*, a small book, not too small, as a pocket-companion, to beguile the tedium of travel in an agreeable and intelligent manner, is likely to command the attention of the public. The book before us weighs only 18 ounces, and measures 5 by $7\frac{3}{4}$ inches, just the size for a bicycle bag or a side-pocket, and is crammed full of information of the best quality and written by an experienced practical geologist, who tells his readers what is to be seen of geological interest on every line of railway and in every separate county in the kingdom, illustrated by 34 maps *coloured geologically*, so that he who rides, by road or rail, can take out his book and *look* or *read* as he is so minded.

Before starting out, the beginner should at least read the first 34 pages, which in clear and simple language will convey to him an outline of what geology teaches about the broad features of our island, and how they have been produced by the agencies of the sea or by rain and rivers, or the slow movements of the solid crust, during vast periods of past geological time: how the old sediments which form our stratified rocks were accumulated and afterwards uplifted, and then slowly carved out into earth's physical features, just as a sculptor might carve the features of a man out of a block of marble, or, as the same thing is sometimes done now, by means of the 'sandblast' process—so our hills and dales and great cliffs and rugged mountains have been slowly carved by atmospheric agencies, ice, snow, frost, rain, and rivers, nay, even by wind and sun, heat and cold.

The reader will get some notion too of the periods of geological time and of the relative antiquity of the various rocks, which he will speedily recognise in the handy little maps of the counties by their several geological colours, first as expressed in the frontispiece of the whole of Great Britain, admirably executed by chromolithography, as Stanford's know so well how to do it. Each geological colour is numbered in the Index on the General Map, and on a larger scale on the single folding-plate (facing p. 1), which gives at a glance the number, colour, and name of each formation and the names of its characteristic fossils. Then, if the reader be going to travel from

London, say, through Middlesex, Hertford, Bedford, or Buckinghamshire, he will turn up Map 2, and tracing his intended route will easily note, by the colours and the numbers, the formations he will travel over, and so will read with greater interest in the pages devoted to each county (pp. 40–101) what are the features of each, both physically and geologically; or in the pages which follow (pp. 102–134), after selecting his line of road or railway, he may read what are the rocks and the kind of country he is about to travel over.

If travelling by road on bicycle or motor-car (or with knapsack and on foot), he may stop a few minutes by roadside section or quarry, or even by a heap of native stones picked off the land or obtained from an excavation near by, and find here and there a fossil which the plates of fossils (xxxv–l) will often enable him to identify. All these details are full of interest to the inquiring and intelligent student who wants to know the inside of things, and for teaching him there is nothing like pictures and colours. The only fear is that such aids to intellectual improvement may be made too easy and agreeable; but though the full-fledged geologist may feel these matters too simple, the less advanced inquirers, of whom there are many, will certainly not be disappointed in the pleasure to be derived from the companionship of this very useful little book.

The original work, entitled "Reynolds's Geological Atlas," which gave the cue to the present volume, and now renamed "Stanford's Geological Atlas," has a history, and has long been known and regarded as a useful companion and guide to those journeying on business or pleasure in Great Britain who take interest in the geology of the country. The first edition, issued in 1860, was prepared with the assistance of the late Professor John Morris, F.G.S. (for 21 years one of the Editors of the Geological Magazine), and the second edition, published in 1889, was revised by the late Mr. Robert Etheridge, F.R.S. L. & E., F.G.S. (*also* one of the Editors of this journal from 1865 to the present year).

The present volume has been carried out upon the general plan of the older work; the text has, however, been entirely rewritten by Mr. Horace B. Woodward, F.R.S. Fuller descriptions of the geological formations, with lists of localities for fossils, have been given; the particulars relating to each county have been amplified, regard being paid to the more interesting geological facts, irrespective of the size or industrial importance of the county, and notes on seaside resorts have been appended.

The descriptions of the geological features observable along the main lines of railway is entirely a new feature. A few of the original text illustrations are the same as in the earlier edition, the others have been borrowed from Sir Andrew Ramsay's "Physical Geology and Geography of Great Britain."

The figures of fossils, forming sixteen double octavo plates, have been reproduced chiefly from Lowry's "Tabular View of British Fossils" and from his "Chart of Characteristic British Tertiary Fossils"; others have been taken from the "Chart of Fossil

Crustacea," drawn by J. W. Salter, F.G.S., and Henry Woodward, F.R.S.; a few are from Ramsay's "Physical Geology." They are very well selected, and will serve to illustrate the forms of the leading fossils that are to be met with in the various British stratified rocks.

The maps in the original atlas were based to a large extent on those published by the Geological Survey, and they have now been revised, as far as the scale has permitted, from the later published maps of that institution and from Sir A. Geikie's Geological Map of Scotland. The work reflects credit on both the author-editor and publisher, and deserves to prove a success, and is certainly a very useful addition to our geological library.

III.—A Guide to the Fossil Mammals and Birds in the Department of Geology and Palæontology, British Museum (Natural History), Cromwell Road, London, S.W. Eighth Edition. 8vo; pp. xvi and 100, with 6 plates and 88 text-figures. (London, 1904. Price 6*d*.)

THE Guides to the Geological Department bid fair to continue to be "the cheap sixpenn'orth" of the Museum. The aggregate sales of the seven earlier editions (1881–1896), we are told, amounted to about 20,000 copies; and we may safely prophesy that the one issued this year will find equal favour with the public.

This work has been entirely rearranged and rewritten; 28 of the text-figures used in the earlier editions have been withdrawn, and 14 new text-figures introduced, 5 octavo plates of fossils, a new geological table of fossiliferous deposits giving British and European names of strata, also a folding plate-plan of the Mammalian and Avian Galleries.

The new illustrations comprise two views of the same block of a Lower Pliocene Bone-bed from Pikermi (near Athens), obtained by Dr. A. Smith Woodward, F.R.S.,[1] together with a large collection of fossil remains in 1901 (see Geol. Mag., 1901, pp. 481–486), crowded with bones of mammals and of birds. The three-toed Horse (*Hipparion*), various bones of antelopes, and some carnivora make up the great mass of the block.

A block of flint from Crayford, Kent, broken by Palæolithic man in making flint-knives, is illustrated on p. 7 as one of the prehistoric series. The restored skull and mandible of the giant lemur, *Megaladapis insignis*, from a cave in Madagascar, is drawn (p. 11), and the gaping jaws and outline of head of the sabre-toothed tiger (*Machærodus*) (p. 13) from South America. After such a yawn, do you think he could ever shut his mouth again? The skeleton of *Hyænodon* from Dakota (p. 16) is also new.

Of wonders added to the collection lately is the skull and mandible of *Arsinoitherium zitteli* (fig. 38, p. 47), a mighty herbivore of the new order Barypoda (see Dr. C. W. Andrews, Geol. Mag., October, 1904, p. 481), from the Upper Eocene of

[1] Author of the present Guide, and Keeper of the Geological Department.

the Fayûm, Egypt, a beast off which the royal sabre-toothed tiger might have dined well after fair fight. The pictured skeleton of *Phenacodus*, like that of *Hyænodon*, are both in American Museums. *Toxodon platensis*, a huge herbivore, is represented by a restored reproduction in the gallery (T). Of the Elephants, there is a new figure of *Elephas* (*Stegodon*) *ganesa* from the Sewaliks of India; and near it (p. 64) is figured the four-tusked *Tetrabelodon*[1] from Sansan, France, the skull and mandible of *Palæomastodon beadnelli*[2] and of *Mœritherium lyonsi*,[3] both from the Eocene of the Fayûm, Egypt.

A new figure is also added of the skeleton of *Glyptodon clavipes* (case Z, pavilion) from the Pampa formation of Buenos Aires (p. 75), and on plate iv pieces of the skin of the extinct ground-sloth, *Gryphotherium Listai*, nearly as large as the *Mylodon*, whose remains, associated with man, were obtained from a cavern near Last Hope Inlet, Patagonia, where these great phytophagous mammals appear to have been kept alive, and fed upon cut grass (also preserved) by these wild people, who afterwards ate them, leaving the bones and skin behind.

The lower teeth of the existing Monotreme *Ornithorhynchus* are figured (p. 85) to show their multituberculate crowns, which closely resemble the teeth of some of the earliest Prototherian mammals found fossil. A figure is added (p. 90) of the restored skull of the great extinct bird *Phororachos*, also from Patagonia; and on pl. v is given a beautiful figure of the skeleton of the gigantic Moa (*Dinornis maximus*) from New Zealand, set up in the gallery some years since. Plate vi gives an excellent figure of the long-tailed and toothed fossil bird, the *Archæopteryx*, from the Lithographic Stone of Eichstädt, Bavaria (described and figured by Dr. Henry Woodward in the *Intellectual Observer*, vol. ii, for 1862).

In the folding table of stratified rocks the range of each great group of organisms is shown in the stratified series, and the approximate European equivalents of the British rocks are given in parallel columns.

In a museum the student is more concerned with the succession of life than with the succession of stratified rock-masses; and a grouping by means of epoch names—that should be used all the world over, if possible—is to be commended.

The fresh column of Ages, as present day, historic, neolithic, palæolithic, glacial, would be excellent if all were simple and accepted terms, but such names as 'Priabonian,' 'Artinskian,' 'Pliensbachian,' etc., have been very little used in this country; it is, however, possible they may be adopted when known and appreciated; but for the people who buy the Guide they do not seem likely to be of much assistance.

Another new column added gives, diagrammatically, the relative lengths of Epochs, with the thickness of each, and anyone who likes may colour this part for himself with great advantage.

[1] See Geol. Mag., Dr. C. W. Andrews, on *Tetrabelodon*, 1903, p. 225.
[2] Article by Dr. C. W. Andrews, see Geol. Mag., March, 1904, p. 113.
[3] See Geol. Mag., March, 1904, p. 110.

Among the figures eliminated from the Guide, we miss the picture of the 'Musk-ox,' and the molar teeth of the Indian and African elephants (useful for comparison); these are probably excluded as living forms, but by the time a new edition is called for we may see the whole of the recent and fossil mammalia and birds amalgamated in one Guide. Signs are not wanting of what Sir Henry Howorth, writing to the *Times*, described as the coming fusion of the Louvre and the Luxembourg Galleries.

IV.—Physiography: an Introduction to the Study of Nature. By T. H. Huxley. Revised and partly rewritten by R. A. Gregory, Professor of Astronomy, Queen's College, London. 8vo; pp. xi, 423, with 301 illustrations. (London: Macmillan and Co., Limited, 1904. Price 4*s.* 6*d.*)

IT was in 1877 that Huxley's "Physiography" was introduced to the public, and to a certain extent it revolutionized, as was the aim of the author, the old method of teaching Physical Geography. He sought to convey scientific conceptions by an appeal to observation; to create interest in the study of 'Earth-knowledge' by commencing with the local geography, "until step by step the conviction dawns upon the learner that, to attain to even an elementary conception of what goes on in his parish, he must know something about the universe." Thus "the knowledge of the child should, of set purpose, be made to grow in the same manner as that of the human race has spontaneously grown."

The original edition of Huxley's book owed much, as the author cordially acknowledged, to the editorial care of Mr. F. W. Rudler. The work became at once popular in the best sense of the term, a third edition was issued in 1880, and it has continued to hold its place with comparatively little alteration until the appearance of the present work. The progress of science during the past quarter of a century has, however, made necessary many additions and modifications in detail, while here and there alteration in plan has been deemed desirable.

The most prominent change is in the omission of the special reference to the Thames and its basin, which Huxley had taken for his 'text'; instead, the central idea has been transferred to any river basin. This difference in treatment is marked when we compare the index of the present volume with that of Huxley's third edition. In the latter there are more than sixty references to the Thames and its basin. In the present index the Thames is not recorded. Considering the interest of the subject, a little more space might have been given to the "Development of a drainage area," as but scant justice can be accorded in a page of print to the views enunciated by Professor W. M. Davis; and his nomenclature of rivers is not even mentioned.

A conspicuous feature in the new work consists in the number of admirable pictorial and other illustrations, of which six only appeared in the old editions; and it is satisfactory to find that while the work

has been thoroughly revised, yet a great deal of the original text has been retained. Moreover, Professor Gregory, whose sympathies may be considered to lean towards the astronomical side of physiography, has very fairly upheld the balance of power allotted by Huxley to the claims of the several sciences concerned in the subject. Physiography is thus kept well within its legitimate bounds of Earth-knowledge, or, strictly speaking, Nature-knowledge, despite the tendency, as Professor Lapworth observed last year in his address to the Geological Society, for "Physiography to embrace much that truly belongs to Astronomy." Professor Gregory, indeed, commences his work in a way that must delight Professor Lapworth, by dealing with "Maps and Map-reading," a subject eminently fitted to interest and instruct, but hitherto strangely neglected in all spheres of society.

The chapter on "Geological Structure and History" contains many effective pictures, but here and there some emendation is required in the text. We are at a loss to interpret fig. 234, "Greensand with boulders at Headington, 2½ miles below Oxford." The 'Lower Greensand' of Shotover Hill, by Headington, rests on Portlandian beds with huge 'doggers'; and at a lower level there is Kimeridge Clay resting on the Corallian Limestone, strata that answer better to the figure than to the legend attached to it. On the same page (331) it is stated that "the hills of Middlesex are formed of London Clay," whereas Stanmore Hill, the highest ground, is capped by gravel; Hendon, Finchley, and Muswell Hill, by gravel and boulder-clay; Harrow, Hampstead, and Highgate, by Bagshot sand. On the next page we find Edge Hill included among the escarpments of the Oolites, whereas, to be precise, it is a scarp of Marlstone or Middle Lias. These, however, are but trifling defects that may readily be put right in a new edition.

V.—Geological Survey of the Transvaal: Report for the year 1903. (Pretoria, 1904. Price 7*s.* 6*d.*)

THE Geological Survey of the Transvaal, as organized under the British Government, was constituted in February, 1903, under the direction of Mr. Herbert Kynaston, B.A., F.G.S. The present report deals with the first year's field-work carried on by the Director and two geologists, Mr. E. T. Mellor, B.Sc., F.G.S., and Mr. A. L. Hall, B.A., F.G.S. It is a folio work of 48 pages, accompanied by 24 plates of pictorial views, sections, plans, and colour-printed maps, all admirably rendered. The area chosen for survey was that to the east of Pretoria, bordering the railway as far east as Balmoral on the way to Middelburg; and the main results of the field-work are depicted on a map on the scale of about 2⅓ miles to an inch. The older stratified rocks include (1) a *Dolomite Series*, (2) shales and quartzites grouped as the *Pretoria Series*, (3) the *Waterberg Sandstones and conglomerates*, (4) the *Karroo System*, comprising glacial conglomerate, coal-measures, etc., and (5) alluvial deposits. Granite, felsite, syenite, elæolite-syenite, diabase, and volcanic breccia are likewise represented. Evidence is brought forward to show that there is

a considerable break between the Waterberg and Pretoria Series. The glacial conglomerate, which lies at the base of the Karroo System, is on the same horizon as the well-known Dwyka conglomerate of Cape Colony. Glaciated surfaces have been met with further north than had previously been observed by Dr. Molengraaff, and the evidence of the striæ and of the boulders indicates that the general direction of the ice-movement was from north to south. Excellent pictures of glaciated surfaces are given. Investigations were made into the diamondiferous deposits of the Schuller, Kaalfontein, and Montrose mines. The diamonds are found in true pipes or volcanic vents, and in alluvial and other superficial deposits. The pipes appear all to belong to the same geological period, and they are evidently younger than the Pretoria Series, into which they have been intruded. There is, however, much resemblance in behaviour and constitution between the pipes now described and those of Kimberley, and if they prove to be contemporaneous the Transvaal pipes would be of post-Karroo age.

Mr. Kynaston and his fellow-workers are to be heartily congratulated on the results of their first year's work in the Transvaal, showing, as it does, abundant evidence of careful scientific research by well-trained observers, who are at the same time keenly alert with regard to questions of economic geology on which their labours are calculated to throw light.

OBITUARY.

ROBERT FISHER TOMES, J.P., F.G.S.

Born 1823. Died July 10, 1904.

Last July the geological world had to mourn the loss of a veteran geologist, Robert Fisher Tomes, of South Littleton, near Evesham. Although he may have appeared to have lived a somewhat secluded life, it was nevertheless an extremely active one. The administration of justice, educational matters, parish and county work, various branches of archæology, zoology, and geology, all received attention; whilst he was an excellent carver of old oak and an enthusiastic collector of old china—especially Worcester. His collections of fossil corals and birds are particularly fine, and he also possessed a number of type-specimens of bats, which unfortunately went to decay owing to inadequate preservation.

Mr. Tomes was born at Weston-on-Avon in 1823, and was the brother of Sir John Tomes, Bart., F.R.S., F.R.C.S., L.D.S., who died in 1895 (an odontologist of no mean rank, and a friend of Sir Richard Owen). He was Vice-Chairman of the Chipping Campden School Board for many years; Chairman of the Board of Guardians of Stratford-on-Avon for thirteen years (until 1879), when he went to live at South Littleton. He was appointed Alderman for the County Council of Worcester; subsequently being placed on

the Standing Joint Committee, on which he remained until his death in July of the present year. His knowledge of geology, especially of the country around Evesham, enabled him to indicate in the Cotteswold Hills places whence water was obtained for the supply of thirteen or fourteen villages. His views met with considerable opposition at first, but were, however, accepted without question by the engineer, and the work was accomplished at a moderate cost.

In 1860 Mr. Tomes was made a Corresponding Member of the Zoological Society of London, in recognition of the labour spent and the excellent results obtained from the examination of the Cheiroptera, and for his descriptions of many new species. His fine collection of birds from the county of Worcester testify to his taxidermic skill and knowledge of ornithology.

About the year, however, that he was elected a Corresponding Member of the Zoological Society, Mr. Tomes directed his attention to geological matters, opening the discussion as to the age of the Sutton Stone and Lias conglomerates of Glamorganshire. The subject was broached in 1863 on account of a *Gryphæa* having been sent by Mr. Tomes to John Jones, of Gloucester, for the purpose of figuring and describing in his paper "On *Gryphæa incurva* and its varieties" communicated to the Cotteswold Club; the stratigraphical position of the fossil having been given by Mr. Tomes as "White Lias of Bridgend, Glamorganshire." The fact that the *Gryphæa* was of great interest if it really occurred in what was known as the "White Lias," was naturally appreciated by Jones, but the fact was contested by Charles Moore, F.G.S., of Bath. Moore denied that Rhætic beds were exposed in the Bridgend cutting; but admitted that if the *Gryphæa* was associated with *Ostrea intusstriata* (*Plicatula intusstriata*), then the evidence for the Rhætic age of the deposit was strong, as it was then generally believed that *Plicatula* only occurred in the White Lias. Accordingly it was agreed that Tomes, Moore, Kershaw, and Gibbs should make a fresh examination of the section. Tomes discovered the little *Plicatula* adhering to a lump of Mountain Limestone firmly embedded in the Lias rock. Near the same horizon a large specimen of *Coroniceras Bucklandi* was discovered by Moore. After an examination of the coast-section in the neighbourhood of Sutton and a re-investigation of the Bridgend cutting (where a *Gryphæa* with "no less than six small specimens of *Ostrea intusstriata*" adhering was found), it was agreed that the species had a much more extended range in time than had been hitherto thought, and therefore could "no longer be looked upon as typical of White Lias." The matter then appeared settled, for Mr. Tomes submitted that there was but one explanation, and that was "that during the period of the deposition of the Rhætic beds *no such deposition* took place at the locality in question [Bridgend]," an opinion he re-stated in 1877, and added, "the Rhætic fauna of that period became in this manner mixed up with that of the true Lias, which was subsequently deposited." He held this opinion to the end, reiterating it in 1903

when dealing with the coral *Heterastræa rhætica*, from the *Avicula contorta* beds of Deerhurst, Gloucestershire.

Mr. Tomes became a Fellow of the Geological Society in 1877, and communicated numerous papers which appeared in the Quarterly Journal of the Society from 1878 to 1903. Whether short or long, these papers—all on fossil corals—embodied the results of critical examination and accurate field-work, although the results arrived at from an examination of the corals were frequently contested by Duncan. To the GEOLOGICAL MAGAZINE he contributed an even greater number of papers on the same subject, always making his own drawings.

L. RICHARDSON.

LIST OF TITLES OF PAPERS BY ROBERT FISHER TOMES, F.G.S.

"On the Position of *Gryphæa incurva* in the Lower Lias at Bridgend": Proc. Cotteswold Nat. F.C., vol. iii (1865), pp. 192–194.

"On the Stratigraphical Position of the Corals of the Lias of the Midland and Western Counties of England and of South Wales": Quart. Journ. Geol. Soc., vol. xxxiv (1878), pp. 179–195, and pl. ix.

"A List of the Madreporaria of Crickley Hill, Gloucestershire, with Descriptions of some New Species": GEOL. MAG., 1878, pp. 297–305.

"On the Fossil Corals obtained from the Oolite of the Railway Cuttings near Hook Norton, Oxfordshire": Proc. Geol. Assoc., vol. vi (1879), pp. 152–165.

"Description of a New Species of Coral [*Thamnastræa* (*Synastræa*) *Walfordi*] from the Middle Lias of Oxfordshire": Quart. Journ. Geol. Soc., vol. xxxviii (1882), pp. 95, 96, and fig. in text.

"On the Madreporaria of the Inferior Oolite of the Neighbourhood of Cheltenham and Gloucester": Quart. Journ. Geol. Soc., vol. xxxviii (1882), pp. 409–449, and pl. xviii.

"On the Fossil Madreporaria of the Great Oolite of the Counties of Gloucester and Oxford": Quart. Journ. Geol. Soc., vol. xxxix (1883), pp. 168–196, and pl. vii.

"On some new or imperfectly known Madreporaria from the Coral Rág and Portland Oolite of the Counties of Wilts, Oxford, Cambridge, and York": Quart. Journ. Geol. Soc., vol. xxxix (1883), pp. 555–565, and pl. xxii.

"A Comparative and Critical Revision of the Madreporaria of the White Lias of the Midland and Western Counties of England, and of those of the Conglomerate at the base of the South Wales Lias": Quart. Journ. Geol. Soc., vol. xl (1884), pp. 353–374, and pl. xix.

"A Critical and Descriptive List of the Oolitic Madreporaria of the Boulonnais": Quart. Journ. Geol. Soc., vol. xl (1884), pp. 698–723, and pl. xxxii.

"On some new or imperfectly known Madreporaria from the Great Oolite of the Counties of Oxford, Gloucester, and Somerset": Quart. Journ. Geol. Soc., vol. xli (1885), pp. 170–190, and pl. v.

"Observations on some imperfectly known Madreporaria from the Cretaceous Formation of England": Quart. Journ. Geol. Soc., vol. xli (1885), Abs. of Proc., pp. 111, 112.

"On the occurrence of Two Species of Madreporaria in the Upper Lias of Gloucestershire": GEOL. MAG., 1886, pp. 107–111.

"On some new or imperfectly known Madreporaria from the Inferior Oolite of Oxfordshire, Gloucestershire, and Dorsetshire": GEOL. MAG., 1886, pp. 385–398 and 443–452.

"On Palæozoic Madreporaria": GEOL. MAG., 1887, pp. 98–100.

"On *Heterastræa*, a new genus of Madreporaria from the Lower Lias": GEOL. MAG., 1888, pp. 207–218.

"Notes on an Amended List of Madreporaria of Crickley Hill": Proc. Cotteswold Nat. F.C., vol. ix (1890), pp. 300–307, and plate.

"Observations on the Affinities of the Genus *Astrocœnia*": Quart. Journ. Geol. Soc., vol. xlix (1893), pp. 569–573, and pl. xx.

"Description of a New Genus [*Stelidioseris*] of Madreporaria from the Sutton Stone of South Wales": Quart. Journ. Geol. Soc., vol. xlix (1893), pp. 574–578, and pl. xx.

"Observations on some British Cretaceous Madreporaria, with the Description of two New Species": Geol. Mag., 1899, pp. 298–307.

"Description of a Species of *Heterastræa* from the Lower Rhætic of Gloucestershire": Quart. Journ. Geol. Soc., lix (1903), pp. 403–407, and figs. in text.

JOHN BELL HATCHER.[1]

Born October 11, 1861. Died July 3, 1904.

The Editor of the *Annals of the Carnegie Museum*, Pittsburgh, Pennsylvania, U.S., records with deep regret the death, on July 3rd, 1904, of his trusted associate, Mr. John Bell Hatcher.

Mr. Hatcher was born at Cooperstown, Brown County, Illinois, on October 11th, 1861. He was the son of John and Margaret C. Hatcher. The family is Virginian in extraction. In his boyhood his parents removed to Greene County, Iowa, where his father, who with his mother survive him, engaged in agricultural pursuits near the town of Cooper. He received his early education from his father, who in the winter months combined the work of teaching in the schools with labour upon his farm. He also attended the public schools of the neighbourhood. In 1880 he entered Grinnell College, Iowa, where he remained for a short time, and then went to Yale College, where he took the degree of Bachelor in Philosophy, in July, 1884. While a student at Yale his natural fondness for scientific pursuits asserted itself strongly, and he attracted the attention of the late Professor Othniel C. Marsh, the celebrated Naturalist, at that time palæontologist of the United States Geological Survey. Professor Marsh, as soon as the young man had received his diploma, commissioned him to undertake a palæontological investigation in south-western Nebraska. From the summer of 1884 until the year 1893 he was continuously in the employment of Professor Marsh. During these years he conducted explorations over a wide area in the States of Nebraska, the Dakotas, Montana, Utah, Wyoming, and Colorado. These expeditions to the western country, which usually began early in the spring, continued until late in the fall, or even into the early winter. He also collected in the winter months and early spring in Maryland and North Carolina. His success as a collector was phenomenal, and the scientific treasures which he unearthed greatly enriched the collections of the United States Geological Survey and of the Peabody Museum in New Haven. It was upon the collections of vertebrate fossils made by J. B. Hatcher that Professor Othniel C. Marsh based to a very large extent many of his most important papers, and to Hatcher more than to any other man is due the discovery and collection of the Ceratopsia, perhaps the most striking of all the extinct reptilia. Very little had been known about them, and before

[1] Reprinted, slightly abridged, from Dr. W. J. Holland's notice in *Annals of the Carnegie Museum*, vol. ii, No. 4 (1900), pp. 597–604.

Hatcher succeeded in discovering a large number of skulls and skeletons they were at best represented by a few fragments, the nature of which was hardly understood even by the most advanced students. At the time of his lamented death Professor Marsh was engaged in preparing a monograph upon this material, and it fell to his distinguished student, who had discovered these colossal creatures, to take up in 1902 the work which Marsh had left unfinished, and he was devoting himself to this work at the time of his death.

In 1890 Mr. Hatcher was made Assistant to the Chair of Geology in Yale University, and in 1893 he was elected Curator of Vertebrate Palæontology and Assistant to the Chair of Geology in the College of New Jersey at Princeton.

While at Princeton he continued his geological and palæontological explorations in the Western States with his usual enthusiasm and success. For many years he had cherished the wish to undertake the exploration of Patagonia and Tierra del Fuego from a geological and palæontological standpoint. He finally undertook the collection of a fund to enable him to carry out this object. Generous subscriptions were made by a number of the alumni and friends of Princeton University, and he himself out of his small savings contributed a large portion of what proved to be required to undertake the work. His plans were thoroughly approved and enthusiastically supported by Professor W. B. Scott, the Professor of Geology in Princeton. Three expeditions were made. The first extended from March 1st, 1896, to July 16th, 1897. On this expedition Mr. Hatcher was accompanied by his brother-in-law, Mr. O. A. Peterson, as an assistant. The second expedition extended from November 7th, 1897, to November 9th, 1898, when he was accompanied by Mr. A. E. Colburn as taxidermist. The third expedition was carried on from December 9th, 1898, to September 1st, 1899, when Mr. O. A. Peterson again accompanied Mr. Hatcher. The story of these expeditions has been published in the first volume of the Reports of the Princeton University Expeditions to Patagonia, which are being issued under the editorial supervision of Professor William B. Scott upon the J. Pierpont Morgan Publication Fund of Princeton University, the fund having been generously given by Mr. Morgan in order that the scientific information secured by Mr. Hatcher might be made known to the world. In the conduct of these expeditions J. B. Hatcher strikingly revealed not only his great scientific insight, but his undaunted courage and great tenacity of purpose. Twice he nearly lost his life, once as the result of a singular accident which befell him while taking a lonely road across the pampas, once while confined to his tent amidst the deep snows of winter by a violent attack of inflammatory rheumatism, from the ill effects of which he never quite recovered.

The results of Hatcher's explorations in Patagonia were of the most important character. The collections of vertebrate fossils made by him and his assistants, and now preserved at Princeton

University, are enormous in extent and of the very highest scientific value. Some of these collections were made by him at great personal risk, the strata in which they were found being only exposed for a few hours at low tide on the margin of the ocean. Working rapidly he and his assistant took up what they could, and then hurried back over the wide beach to the cliffs, to presently see the water from fifty to sixty feet deep rolling over the spot where they had been excavating. The explorers literally snatched their treasures from the hungry jaws of the ocean. In the fields of recent zoology and botany he made extensive collections. His geographical discoveries were of great importance. He added immensely to our knowledge of the interior of Patagonia, traversing vast territories upon which civilized man had never before planted foot. He discovered mountains and lakes, and traced the course of rivers which had never before been mapped. One of the great mountain ranges, by the consent of both the Argentine and Chilian Governments, bears his name. His decision that the crest of the Patagonian watershed in parts of its course lies far east of the crest of the southern Andean ranges, had an important bearing upon the question of the boundary-line between the Argentine Republic and Chile, and in the arbitration of this question, which has happily been settled without recourse to arms, as was at one time threatened, the discoveries of the young American explorer were brought into prominence in diplomatic circles.

On February 1st, 1900, J. B. Hatcher accepted the position of Curator of Palæontology and Osteology in the Museum of the Carnegie Institute in Pittsburgh, where his brother-in-law, Mr. O. A. Peterson, immediately after his return from Patagonia, had been employed as an assistant. Installed in his new post, with the assurance of the unqualified and generous support of the founder of the Institute in all wise efforts to make his work successful, he began to lay out in connection with the Director of the Museum plans to create one of the most important palæontological collections in America. For four summers in succession he carried on explorations in the Western States. In 1903 he was associated for a portion of the time with Mr. T. W. Stanton, of the United States Geological Survey, in an effort to ascertain the relative position and geological age of the Judith River beds, which had been for some time the subject of earnest discussion among geologists. His views in relation to this subject, which had been opposed by almost every other geologist in America, were finally ascertained to be correct, and it was a matter of great personal gratification to him, as the writer of these lines knows, that the accuracy of his observations and of his conclusions, which had been reached many years before, had been verified.

While Professor Hatcher wrote very little in relation to geology, he nevertheless was regarded as being one of the very ablest of American geologists, his great experience in the field and his close attention to the subject having given him a practical knowledge such as was possessed by few of his contemporaries. One of the

leading geologists in America, in speaking of him said to the writer, "I regard Professor Hatcher as one of the best informed geologists in the United States. He is pre-eminent in this field, though he sets comparatively small store by his attainments."

The last five years of his life, during which he was connected with the Carnegie Institute, were not only years in which he proved himself remarkably successful as a collector, but in which he revealed his ability as a scientific author. A number of important papers from his pen have appeared in the Annals and Memoirs of the Carnegie Museum. The first volume of the Reports of the Princeton University Expeditions was written by him during this time. He contributed numerous brief articles to various scientific journals, and in 1902 undertook for the United States Geological Survey the completion of the Monograph of the Ceratopsia which had been left unfinished by Professor Marsh at the time of his death. The writer believes that this great work had been brought so far that it will be possible to complete it with comparatively small effort on the part of some one reasonably familiar with the subject. Various other important papers of a monographic character had been begun. Unfortunately these for the most part are not in such condition that they can be published.

One of the great undertakings which had occupied much of his time and thought during the past eighteen months was the reproduction of the skeleton of *Diplodocus carnegiei*, a restoration of which had been ordered by Mr. Andrew Carnegie for the purpose of presentation to the British Museum of Natural History, the Trustees of which in February, 1903, had formally signified their acceptance of Mr. Carnegie's kind offer to have such a reproduction made for them. The superintendence of this work was a most congenial labour to him. On the 1st day of July, 1904, a small company of scientific men and women, together with the Trustees of the Carnegie Institute, had the pleasure of a private view of this restoration, which had been temporarily set up prior to its shipment to England. The absence of Professor Hatcher from the little company was feelingly alluded to by many. But none of the party dreamed, although he was known to be seriously ill, that he had reached the end of his life's work.

Mr. Hatcher's position as a palæontologist was unique. He is universally admitted by those who are most competent to pass judgment to have been the best and most successful palæontological collector whom America has ever produced. The larger proportion of the choicest vertebrate fossils now in the Peabody Museum at Yale University, in the collection of the United States Geological Survey, in the Museum of Princeton University, and in the Museum of the Carnegie Institute at Pittsburgh were collected by him. To a very large extent the American methods of collecting such remains, which are now universally admitted to be the best known, were the product of his experience in the field and of his careful thought. In a letter just received by the writer from Professor Henry Fairfield Osborn, the Palæontologist of the United

States Geological Survey, he says, alluding to the death of Professor Hatcher: "I can hardly tell you how shocked and grieved I am. I had often thought of the probability of Hatcher's death while in the field when taking great risks and entirely away from medical and surgical attendance, but of his death at home I had not thought a moment. In his intense enthusiasm for science, and the promotion of geology and palæontology, and the tremendous sacrifices he was prepared to make, and *had made*, he was a truly rare and noble spirit, the sort of man that is vastly appreciated in England and in Germany, but I fear very little appreciated in America. His work as a collector was magnificent, probably the greatest on record."

Professor W. B. Scott, in the columns of *Science*, says: "Hatcher may be said to have fairly revolutionized the methods of collecting vertebrate fossils, a work which before his time had been almost wholly in the hands of untrained and unskilful men, but which he converted into a fine art. The exquisitely preserved fossils in American museums, which awaken the admiring envy of European palæontologists, are, to a large extent, directly or indirectly due to Hatcher's energy and skill, and to the large-minded help and advice as to methods and localities which were always at the service of anyone who chose to ask for them." Testimony of like character as to the great achievements of Professor Hatcher has come from many other sources.

Hatcher was an indefatigable student and a very keen observer. He was fertile in resources. He had great mechanical aptitudes, and succeeded, sometimes when alone, by patient effort in accomplishing apparently impossible tasks in the removal of huge and weighty objects from difficult positions, which would not have been undertaken by others. The writer recalls one or two cases in which he dared great physical risks and even death, when alone, far from human companionship, in extracting large masses from their original position and moving them by a skilful arrangement of levers to points where they could afterwards be taken up. One such instance occurred in the autumn of 1903, and the writer could not refrain, while admiring the courage and skill displayed, from earnestly warning Mr. Hatcher against the repetition of such risks as he at that time assumed in attempting to handle a block of rock weighing nearly a ton without the assistance of other men.

While accomplishing a vast amount of most important work during the last five or six years of his life, there was hardly any time in which, as the result of the illness and exposure which he had undergone in Patagonia, he did not suffer pain, and at times of a most excruciating character, and yet he was patient and uncomplaining.

Perhaps the most striking characteristic of Mr. Hatcher was his extreme modesty. He was always reticent in speaking of what he had done, and shunned publicity other than that which came to him through his scientific writings.

Hatcher was a most charming companion, and when he could be prevailed upon to relate the story of his adventures in strange and distant places, the listener found his companionship fascinating.

Though living so much of his life in the wilderness, he was a man of strong domestic attachments. He loved his home, and to none of all the wide circle of his acquaintance does his untimely death bring deeper and more poignant grief than to his wife and four young children. To them the writer renews in these lines his expression of the deepest sympathy. W. J. Holland.

MISCELLANEOUS.

Deslongchamps' Types of Jurassic Brachiopoda.—The British Museum (Natural History) has received a valuable donation, one particularly interesting to students of British Jurassic Brachiopods. It consists of about 100 plaster casts of the types (holotypes, hypotypes), etc., of the Jurassic Brachiopoda figured by E. Deslongchamps in the Paléontologie Française Terr. Jurass., with a few other treasures of the Deslongchamps Collection figured elsewhere. Among the latter is a cast of the holotype of the very rare *Rhynchonella Deslongchampsi*, Davidson—the Museum already possesses the historic Tesson example of this species; also a cast of the holotype of *Terebr. biplicata* (Brocchi), which is not a Cretaceous fossil at all, but is a Jurassic *Ornithella*. Among the Pal. Franç. specimens the examples of *T. conglobata*, *T. Ferryi*, *T. Jauberti*, and others of Deslongchamps' species will be of especial interest. The Director, Professor E. Ray Lankester, F.R.S., has presented this fine series to the Museum.

Mr. C. Fox-Strangways, who joined the staff of the Geological Survey under Sir Roderick Murchison in 1867, has retired from the public service. During the course of his long, detailed, and invariably careful work in the field, he has surveyed large areas in Yorkshire, including portions of the great Coalfield, the country around Harrogate, and most of the moorlands and wolds of the North and East Ridings. Thence crossing the Humber he continued work in North Lincolnshire, and finally passed on to Leicester, from which town as a centre he has re-surveyed the Leicestershire Coalfield, Charnwood Forest, and a large area extending from the borders of the Warwickshire Coalfield across the Liassic vale east of Leicester. The results of this work have been published in numerous maps, sections, and memoirs, amongst which may be mentioned two volumes dealing particularly with the Jurassic rocks of Yorkshire. Apart from his official work Mr. Fox-Strangways has stirred up much local interest in geology in the localities where he has lived and laboured, especially at Leicester, where his services in conducting excursions have been frequently given, and have always been highly appreciated.

Cotteswold Naturalists' Field Club.—The President, Dr. C. Callaway, refers (Proc., vol. xv, part 1) to the loss sustained in the death of their old member Robert Etheridge. After